Travel Model Improvement Program

Conference Proceedings
August 14 to 17, 1994
Fort Worth, Texas

TMIP

Travel Model Improvement Program

Department of Transportation
Federal Highway Administration
Federal Transit Administration
Office of the Secretary

Environmental Protection Agency

Department of Energy

U.S. Department of Transportation

U.S. Environmental Protection Agency

Travel Model Improvement Program

The Department of Transportation, in Cooperation with the Environmental Protection Agency and the Department of Energy, has embarked on a research program to respond to the requirements of the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991. This program addresses the linkage of transportation to air quality, energy, economic growth, land use and the overall quality of life. The program addresses both analytic tools and the integration of these tools into the planning process to better support decision makers. The program has the following objectives:

1. To increase the ability of existing travel forecasting procedures to respond to emerging issues including: environmental concerns, growth management, and lifestyle along with traditional transportation issues,

2. To redesign the travel forecasting process to reflect changes in behavior, to respond to greater information needs placed on the forecasting process and to take advantage of changes in data collection technology, and

3. To integrate the forecasting techniques into the decision making process, providing better understanding of the effects of transportation improvements and allowing decision makers in state governments, local governments, transit operators, metropolitan planning organizations and environmental agencies the capability of making improved transportation decisions.

This program was funded through the Travel Model Improvement Program.

Further information about the Travel Model Improvement Program may be obtained by writing to

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Preface

The travel forecasting models currently in widest use today were developed more than 25 years ago, primarily to evaluate alternative major highway capital improvements. In the 1970s the models were adapted for use in planning major transit capital facilities. These current models were not intended to evaluate congestion pricing, transportation control measures, alternative development patterns, or motor vehicle emissions. It is not surprising that they are not well suited to the tasks needed to meet the planning and air quality requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) or the Clean Air Act Amendments (CAA).

To address current model deficiencies, the Federal Highway Administration, the Federal Transit Administration, and the Office of the Secretary, U.S. Department of Transportation; the U.S. Environmental Protection Agency; and the U.S. Department of Energy have initiated a major program to enhance current models and develop new procedures. The Travel Model Improvement Program (TMIP) is a cooperative effort among organizations involved in transportation, land development, and environmental protection. The program will seek active technical involvement and financial participation from state departments of transportation (DOTs), local governments and metropolitan planning organizations (MPOs), environmental agencies, and private sector entities.

The objectives of the Travel Model Improvement Program are:

- To increase the policy sensitivity of existing travel forecasting procedures and their capacity to respond to emerging issues including environmental concerns, growth management, and changes in personal and household activity patterns, along with the traditional transportation issues.
- To redesign the travel forecasting process to reflect today's traveler behavior, to respond to greater information needs placed on the forecasting process, and to take advantage of changes in data collection technology; and,
- To make travel forecasting model results more useful for decision makers.

The Program is being conducted in four tracks, each with a specific purpose and product. Track A, Outreach, will help practitioners improve their existing planning procedures to be consistent with currently desirable practice. This outreach will be a continuing program of training, technical assistance, research coordination and a clearinghouse for research findings.

Track B, Near Term Improvements, is a program of technical activities to help MPOs and state DOTs elevate current practice to the state of the art. These efforts will implement model improvements already developed but not widely included in current transportation, land use, and air quality planning activities.

Track C, Longer Term Improvements, involves major research and development of new approaches to travel and land use forecasting. Issues and questions, and the roles of models in providing information to address them, will be determined. This research will advance the state of the art of travel and land use modeling to meet those needs.

Efforts in Track D, Data Collection, will identify, design and develop improved data collection procedures that will meet decision makers' current and future needs. Data will be collected to assist practitioners in meeting the requirements of the Intermodal Surface Transportation Efficiency Act and the Clean Air Act, to improve existing models and to develop new procedures.

The travel forecasting issues and needs of the transportation and environmental planning communities must be identified to develop an agenda for TMIP that will best serve these communities. Additionally, the approach and elements of research needed in travel forecasting must be further defined. The TMIP sponsored a workshop conference to accomplish these tasks. The purpose of this conference was to bring together experts and practitioners to:

- Review and receive comments on the work that has been accomplished and the work currently being conducted in Tracks B and C of TMIP.
- Receive input on additional short- and long-term research that should be conducted as part of TMIP.
- Gather information on the data and training needs of practitioners to assist in establishing the work to be conducted in Tracks A and D.

The first day of the conference focused on Track B, Near Term Improvements. Research that has been or is currently being conducted under this track, as well as related research being conducted by others, was presented during the morning session. Following these presentations, participants divided into workshops to discuss the short-term research needs to improve existing models and analytical techniques.

On day two of the conference, efforts were directed toward research in Track C, Longer Term Improvements. During the morning, participants heard presentations on TRANSIMS (TRansportation ANalysis and SIMulation Systems), the new model approach undertaken by the Los Alamos National Laboratory. The Tuesday workshops then focused their discussions on TRANSIMS and other longer term model research needs that must be addressed to perform current and anticipated future planning and policy analyses.

Wednesday workshops concentrated on the issues of deployment, dissemination and education, associated with Track A, Training and Technical Assistance, and on the data needed to support continued research in Tracks B and C as well as to support new model approaches as outlined under Track D, Data Development. Workshop participants also prepared a summary of priority recommendations for the TMIP program.

This report presents a summary of the conference presentations and highlights the recommendations made by the workshop participants. It is anticipated that future conferences will be held to provide continuous outreach and direction to the TMIP.

Introduction

Keynote Address: Evolution and Objectives of the Travel Model Improvement Program

by Martin Wachs, Ph.D., University of California

Twenty-one years ago, in 1973, Douglas Lee published an article in what was then the *Journal of the American Institute of Planners*, entitled "Requiem for Large Scale Models." In that article, which has been widely quoted and reprinted, discussed and debated, Lee argued that the modeling movement had failed and that large-scale regional activity location and transportation models were dead and should be buried. His criticisms were really leveled against models of land use and urban form, models which distributed activities in space, but many of us in the transportation planning community recognized his assault as generic and inclusive of the urban transportation planning modeling process. Lee couched his argument, as many of you will recall, in terms of what he called the seven deadly sins of modeling. The seven sins were:

1) Hypercomprehensiveness: Meaning that the models tried to replicate too complex a system in a single shot, and were expected to serve too many different purposes at the same time.

2) Grossness: In a way, the converse of hypercomprehensiveness. Even though they tried to do too much and serve too many purposes, their results or outputs were too coarse and aggregate, too simplistic to be useful for complicated and sophisticated policy requirements.

3) Data Hungriness: Even to produce gross outputs (a few variables), the models required us to input many variables for many geographic units, and from at least several time periods in order to produce approximate projections, and very often we could not afford the data collection efforts needed to run the models. In other instances, data simply didn't exist at the levels of specificity which would be appropriate to run them.

4) Wrongheadedness: Lee meant that the models suffered from substantial and largely unrecognized deviations between the behavior claimed for them and the variables and equations which actually determined their behavior. As an example, when regional averages were used to calibrate models, but forecasts were made for local areas, the models deviated from reality because of specification errors which were often not even recognized by their users.

5) Complicatedness: Even though when you looked at them through one set of lenses the models seemed terribly simplistic, when looked at through another set of lenses they were outrageously complex. Too simplistic in replicating urban economic and social processes, the models were too complex in their computational algorithms. Errors

were multiplied because there were so many equations, spatial units, and time periods. Even the theoretical notion of the model or its representation of an urban process was grossly simplistic compared with reality. Often, the user didn't know how the errors were propagated through series of sequential operations; and sometimes we needed to use systematic adjustments or "correction factors" to make the models more realistic even though we did not completely comprehend the sources of all the errors and could not interpret the correction factors in real-world terms.

6) Mechanicalness: Lee meant that we routinely went through many steps in a modeling process without completely understanding why we did so, and without fully comprehending the consequences in terms of validity or error magnification. He stated, for example, that even rounding errors could be compounded beyond reasonable bounds by mechanical steps taken to calibrate and apply many models without the user's knowledge.

7) Expensiveness: The costs of the models, derived from their grossness, data hungriness, complicatedness, and so on, placed them beyond the financial means of many agencies, or depleted the resources of agencies so much that the very use of models precluded having the resources available to improve them or to fine tune them to make them appropriate to their applications.

Lee argued in 1973 that the models should be improved in four ways:

1) Models should be made more transparent to users and policymakers.

2) Models should combine strong theoretical foundations, objective information, and wisdom or good judgment. Without these elements, they remain exercises in empty-headed empiricism, abstract theorizing, or false consciousness of what is actually going on in our urban areas.

3) We should start with problems and match our methods to the needs of particular situations, gathering no more information and using no more modeling complexity than is really needed.

4) We should build the simplest models possible, since complex models do not work well, and certainly are unlikely to be understood by those who are asked to act on the basis of the model outputs.

These points remain good advice, but the context in which we try to address them has changed constantly, in part because of advances in computing, GIS, and so forth. I hope you will address these assertions in the workshops which we will have over the next several days.

In a symposium issue of the *Journal of the American Planning Association* which was designed to reconsider Douglas Lee's arguments 20 years later, a very wise man named Britton Harris criticized Lee's paper in retrospect, arguing that the force of Lee's arguments gave modelers such a sense of futility and hopelessness, that many of the best minds, and perhaps more importantly some of the best funding agencies, turned away from urban and transportation modeling for decades, convinced by Lee that there was no hope for dramatic improvements and no point in marginal improvements. Other brilliant people, several of whom are present, continued to refine and adapt models and research new approaches to travel demand forecasting and network performance. Even those people who know it better than the rest of us realize how inadequate today's modeling capabilities are in comparison with the need and with advances made in recent decades in other fields.

Despite Douglas Lee's criticisms and those of many other thoughtful people, travel demand modeling continued to be used on a very wide scale. Commercially available software packages made the models widely available to consultants and agencies. Legislation and regulation made it almost a necessity to use travel forecasting models despite their many limitations and flaws. Air quality analysis requirements led to a long chain of sequentially applied independent models in which outputs of one become inputs to another: from land use or urban activity models to vehicle ownership models to trip generation, trip distribution, mode split, and traffic assignment to pollution generation to pollution dispersion models.

Where are we in 1994? When I look at the state of the art and practice of urban land use, urban transportation, and environmental modeling and the connections between them, I see an extremely disappointing picture made up of at least six disturbing dimensions.

First, the problems which Lee diagnosed are, in my opinion, still with us to a great extent. The problems he noted have not gone away, in some cases because even after more than 20 years the models he criticized are still the very same ones in use today. Our models, by and large, continue to commit the seven deadly sins about which he talked.

Second, the models we use today reflect some progress, but limited progress, in comparison with what we need when it comes to incorporating new forms of data collection and management, such as Geographic Information Systems, and rapidly increasing computing power. The models have not yet taken sufficient advantage of new knowledge and new capabilities in these areas.

Third, I see modelers in some areas who seem content to use inadequate, out-of-date models which fall short of modern capabilities. They are content with these models in part because nobody demands more of them; in part because they don't have the resources or the staff to expand and improve their models; and in part because in some cases they do not even have the training and the skill to recognize that they are falling short of any reasonable standard.

Fourth, I see software vendors and a consulting community which continues to offer clients inferior models at high prices because the clients are not sufficiently sophisticated to demand more, and because the consultants live in a world of competition in which dollars spent on development are not recouped from contract fees. Thus, the pressure is always there to apply what models we have rather than to tailor more advanced models more directly to the needs of policymakers. Our existing capabilities, unfortunately, then become a brake on efforts to forge new capabilities. But our existing capabilities are behind the needs of our time.

Fifth, I see a group of academic colleagues in the field of travel demand analysis who have focused on subtle nuances of travel behavior, elevating our understanding of travel choice behavior to a sophisticated science which is discussed in arcane language that gets ever farther removed from the consultants and practitioners and from the immediate needs of policymakers. We need to find ways of getting this large and fascinating body of knowledge to be more accessible to practitioners and policymakers in the form of usable applications, packages and training programs. The responsibility for doing this has to be shared. There are roles for academics, consultants, the federal government, and the MPOs.

Sixth, I see the federal government, whose demanding planning requirements and financial support in the sixties and seventies, made research, development, and dissemination of model improvements a lively area of concern for a community of scholars, consultants, and clients, doing relatively little since the beginning of the eighties to either promote research on model advances or to require modeling applications which are a step beyond the existing poorly performing models.

For all these reasons, the models our practitioners use today for land use, travel forecasting, and air pollution analysis have not been seriously recast to address the policy issues of the nineties, such as air quality, transportation demand management, parking management, and road pricing, that are decidedly different from the policy issues of the sixties, which largely dealt with facility location and sizing. Practitioners do not have the tools to do the required analyses; agencies do not have the resources to push their capabilities into these new directions; and, scholars are not worrying about how to bridge the gap between theory and practice. Additionally, federal requirements and regulations are not pushing the state of the art, and federal dollars have, until recently, been just a trickle in comparison with what is needed to address this problem.

In 1972 I somewhat proudly told my transportation planning students how complex issues in health care were being addressed mostly without advanced and sophisticated models, while modern freeway and transit systems were being planned and designed with the aid of advanced analytical tools. In 1994 we are still facing health care reforms in a disorganized, unscientific way on the basis of polemics rather than persuasive analysis. Unfortunately, today we seem to be addressing transportation problems as we are health care reform; methods of analysis in our field having become <u>less</u> important to policymaking; <u>less</u> influential in decision making than they were two decades ago. Worst of all, though many of us recognize this failure to advance in transportation analysis, we are a divided community, blaming one another for our problems instead of pulling together to solve them. We know how computing technology has improved and how GIS capabilities increase the potential for travel demand analysis. We know that meeting air quality problems demands more of travel demand modeling than we can adequately deliver, and we know that new understandings of travel choice behavior are not adequately incorporated into our standard modeling practice. We all look to each other to take the lead in overcoming these problems. Agencies blame their consultants, consultants blame funding agencies and academics blame federal officials.

I would like us to vow to make this conference and the Travel Model Improvement Program landmarks in turning this situation around. While there are enough problems and there is enough blame to go around, we all recognize the primitive state of our modeling capabilities in practice in relation to planning and policymaking requirements, and we also can easily see the other side of the coin. There is also more than enough opportunity to be shared in this business, to get excited about. Academics should and could be bringing their new understandings before the community of practitioners; consultants should and could be upgrading the standard capabilities of the studies they perform; agencies should and could be upgrading their staff capabilities, software and hardware; software vendors should and could be putting forward new packages so that progress in transportation and air quality analysis might be at least as dramatic as progress in video gaming; the federal government should and could be exerting more leadership and providing more sponsorship in making all of this happen.

In light of the demands of the Clean Air Act Amendments and the ISTEA, the fledgling Travel Model Improvement Program (TMIP) is one mechanism by which the federal government is attempting to play an active role in this realm. TMIP has participation from several different agencies within the federal government: the Federal Highway Administration, the Federal Transit Administration, the Office of the Secretary of Transportation, the Bureau of Transportation Statistics, the Environmental Protection Agency and the Department of Energy. Each agency is represented in decision making about the program and each is funding at least some of its components. We envision a time period at least on the order of five years to accomplish the goals of this program, and perhaps longer. The effort is still very modest, with only a few people in each agency, and quite fragile in terms of financial and political support. It needs our vocal support if it is to move ahead.

An important goal of this program is to increase the policy sensitivity of travel forecasting procedures to allow us to do a better job of testing policies related to growth management, air quality, and energy conservation through applications of travel demand modeling.

Another goal is to advance the capability of travel demand models as reflections of new knowledge about travel behavior, new data collection and data management capabilities, and new computing capabilities.

The TMIP includes a review panel composed of representatives of various interest groups, transit operators, councils of governments, environmental interests, the real estate development community, and a couple of academics, who look over the shoulders of the U.S. government agencies, and offer advice and counsel. I have the pleasure of chairing the review panel, and it is in that capacity that I was selected to welcome you to this conference. As members of the review committee, we agree not to have any financial attachments to this program. No funded research, for example, will go to review panel members. The review committee is only one of several mechanisms by which the TMIP is seeking to reach out to the professional and client communities. Other ways are by hosting conferences like this one at which your views will be the centerpiece, and by publishing a series of newsletters, research reports and advisory reports over the coming years.

The Monday morning session will present some of the results of research already conducted with sponsorship of the TMIP and some recommendations regarding near-term model improvements to the existing travel forecasting methods kit bag, and so is associated with Track B. A series of research contracts has been let to consulting firms and academics under this track and some of the principals of these studies will be presenting their research results early Monday.

On Tuesday the focus will shift to progress made under Track C, longer term efforts to achieve fundamentally new approaches to travel demand forecasting. As you will see, most of the work undertaken under Track C to date has been conducted by Los Alamos National Laboratory, under the rubric of TRANSIMS.

Wednesday we will be talking more about Track A and Track D and the focus of our discussions will be on deployment, dissemination, education, commercialization.

Many of you already know that the TMIP is a controversial program. I suppose it is inevitable that when funding starts to become available in an area which has been inadequately supported over the past decade and a half, there would be vigorous disagreements over priorities and preferences. Whatever strategy is adopted, each one of us could think of an approach which we would personally prefer. Believe me, there have been vigorous disagreements within our review panel, between the review panel and the federal staff, between the larger research community, consulting community, software vending community and the federal staff who are administering this program, between senior federal officials and those closest to the program on a daily basis. I suppose such disagreement and debate is healthy, and perhaps no ambitious program, whether the space exploration program, the interstate highway program, or the model improvement program, can be born in a peaceful, friendly, uncontentious atmosphere. But let me say just a few words about some major points of disagreement so far.

Each of the four tracks of the Program is important in its own right, and very importantly, there will be coordination among tracks. We have not yet achieved the level of funding needed for all of the tracks, but we hope to do better. It is clear, for example, that so far many more resources have been allocated to Track C and quite a bit more to Track B than to Track D, the Data Development effort. I am particularly interested in Track D, and am assured and reassured that the uneven progress to date is not a reflection of priority as much as it is of funding opportunities which involve complex negotiations. In a five-or-more year program not every priority can be addressed at exactly the same time. I am going to use these workshops to lobby for my priorities, and of course you are all invited to do the same. It would be a mistake, however, to interpret funding allocations made so far as the sole indicator of program priorities. There is a lot more to come.

Secondly, I know that some of the academic researchers present would have liked a larger share of the action. They wanted this program to promote research which advances our understanding of travel behavior and have complained that the program as conceived is too applied. The TMIP is admittedly aimed at advancing the state-of-the-practice in the world because the state of the practice is, as I said earlier, appalling in comparison with the societal need for better travel demand modeling. I agree with this priority, and yet I believe there will be many, many opportunities funded under this program to conduct basic research on travel behavior in order to close gaps in our knowledge and to build better bridges between theory and practice. The doors of this program are wide open to travel behavior researchers who want to join in our effort to improve travel modeling in practice, and who want to apply ongoing research to the building of usable products. But the emphasis on usable products is to my mind quite appropriate.

Thirdly, I am aware of the fact that some of you are skeptical about the award of a large contract to Los Alamos National Laboratories for the purpose of taking a new and fresh look at simulating travel patterns. At Los Alamos, experienced, sophisticated, and extremely competent modelers and computer scientists are paying attention to our interests, but they are new to our community and it is natural to feel a bit uncomfortable about their involvement. The obvious question in some of your minds is: Why not award the funds to people who have a track record in our field, whose expertise and familiarity with travel and transportation are clearly established? There are several reasons for involving Los Alamos, all of which should be considered.

One is their world-renowned expertise in simulation which gives rise to the possibility that a new look, a fresh approach might just offer a way of approaching problems that is exciting because it is a bit different from what one might expect from the people having a great deal of experience in the field. Another is their astounding computing capacity which allows them to try a wider range of simulation approaches than most of the rest of us. A third reason is that the funding which became available to involve Los Alamos in this program WAS NOT available for other purposes. It could not have been given to others.

While many of us reacted to the funding of Los Alamos as if a very large piece of a small pie was going to the laboratory instead of to us, the truth may be just the opposite. That is, by virtue of the considerable progress being made at Los Alamos so far, and the demonstration of exciting new capabilities for travel modeling which is going on there, I think that more funding will become available for travel behavior analysis and modeling. In other words, the pie will be larger because of their work, and the rest of our community of interest will benefit from the collective attention given to travel models in part as a result of the work at Los Alamos. I think you will be impressed with the progress the Los Alamos team has made in an amazingly short time. I hope we can focus on synergies: the ways in which the Los Alamos work can be integrated with work done by many of us in the room. And it is in the synthesis of their innovations with the deep understandings of travel behavior which others here can bring to the table, that I think the most progress can be made.

This is a workshop conference, and each and every one of us is a participant. We have kept the presentations to a really small proportion of the total time, and the majority of the time is devoted to interactive discussions. We encourage your vigorous, active participation. We are delighted by the turnout which far exceeded our expectations, and we hope that you will in the year 2014 - by which time transportation modeling will be flawless - refer to the Fort Worth conference as the source of some of the best ideas which helped us modernize and improve travel forecasting and analysis during the coming 20 years.

Workshop Recommendations

The recommendations presented here were prepared in six workshops. Each met twice, once to recommend improvements to existing models and procedures and again to address the research needed to develop new models specially designed to meet today's requirements. A second set of workshops met on the last day of the conference to prepare recommendations for implementing and deploying the new and improved travel models. The workshops prepared lists of needed research and related activities that were summarized in the plenary sessions. The following descriptions of recommended actions are taken from those workshop lists and from additional commentary recorded during the sessions by workshop reporters. The recommended research and other actions are presented in groups that address particular aspects of the transportation planning process. Within those subject groups the recommendations are further categorized in more detail. Included among the recommendations are criteria which should guide the development of the new

KEY RECOMMENDATIONS

- The sensitivity of land use and travel models to emerging transportation policies should be improved.
- Research is needed to identify household and individual activity characteristics that influence trip chaining.
- Trip generation models should be sensitive to the type and level of transportation services.
- Research is needed on choice of trip destination and travel mode for non-work and non-home based trips.
- Information is needed on changes in travel behavior over time to accurately predict future travel.
- Models need to be developed for forecasting movements of freight, goods and services.
- Research is needed to improve understanding of the potential for congestion relief from non-motorized and non-transportation modes.
- Research is needed to improve land use forecasting procedures and to effectively integrate those with travel forecasting procedures.
- Better understanding is needed of the influences of vehicle characteristics and operating conditions on motor vehicle emissions.
- Considerable need exists for training all levels of practitioners in various types and sizes of transportation planning organizations.
- Improved communication and timely dissemination of information among transportation planning practitioners is needed for sharing problems, solutions and advancements.

and improved models. While not specific research actions, these criteria indicate the kinds of considerations and procedures that should be followed to produce models that satisfactorily meet today's travel forecasting needs.

Travel Model Improvements

The recommendations begin with general recommendations for research and criteria applicable to models in general or broader aspects of travel forecasting. These are followed by specific recommendations for individual model types.

A key concern about improvements to travel forecasting models is that they should focus strongly on the role of models in policy development and other decision making. The new models must be sensitive to emerging transportation policies such as pricing, travel demand management, other transportation control measures, and roadway lane use restrictions. The new models must also be both efficient and accurate, capable of providing credible answers quickly, under political pressure, in response to the needs and questions of today's decision makers.

The forecasts resulting from the new and improved models must be reasonably tractable and logical to withstand the scrutiny necessary to sustain credibility with their audiences. The new models must be capable of producing credible and consistent answers at different scales, regional, corridor and subarea. The models should be rigorously validated according to generally recognized criteria established jointly by planning, funding and operating agencies and professional organizations. The validations should be conducted for more than one year to assure that the models are sensitive to changes in conditions that affect travel behavior. The validations should provide measures of accuracy and confidence for the forecasts they produce, in terms of probabilities that reflect the randomness and inherent variability of individuals' travel choice behavior. Comparison of previous forecasts to actual outcomes should be undertaken systematically to understand if and why those forecasts were inaccurate and to modify future procedures to accommodate any problems. The micro simulation models being developed must be capable of forecasting accurately and not just replicating existing conditions.

The models resulting from this research must be capable of testing alternative scenarios with consistency. The models should be transferable between applications and locations. A test of transferability and consistency at different scales of developed area and locations would be appropriate, comparing results for Los Angeles and Albuquerque for example. It remains desirable that the models contain default parameters but are also amenable to localized-customization. It is important that the model development research be mindful of the use of the new models for air quality conformity analysis in order to produce the kind, detail, and accuracy necessary for that work. The models must also be capable of incorporating the effects of intelligent transportation system improvements.

The models should provide understandable transportation system performance measures for use in comparative evaluation of alternatives. Those measures must include transportation cost information for use in the financial planning process.

More specific recommendations for research and criteria for specific models and other aspects of the travel forecasting process are provided in the following paragraphs.

Travel Behavior

Research is needed on household activity behavior that results in travel choices. This should include investigation of how households select activities and allocate resources for travel, especially time, money, and vehicle use. This research should relate the choice behavior to the life-style and position in the life cycle of household residents. The behavior of similar households should be followed over time to see how it changes as conditions in the households change. In particular the research should identify established, changing and emerging habit patterns of activity and choices and the inertia or reluctance to change those patterns under various conditions and influences. This work will help to understand the stability or flux of travel model parameters over time. The research should lead to improved understanding of households' and members' utilities or values that affect their preferences and choices among travel options. Those preferences are what will drive the travel models.

The research should examine the choices, sequences and durations of activities and relate them to the resultant chaining of trips and the timing and routing of the travel of households and their members. The choice of departure time is important for its influence on peak spreading. Factors influencing the choice or allocation of vehicle use and their relation to characteristics of the assigned driver and the resulting trip should be determined because that will influence motor vehicle emissions. The research should also consider the interaction among the several choices that influence travel characteristics; for example, activity type affects trip destination, which affects timing and possibly mode. Factors inducing new travel or changes in travel characteristics should be studied for their possible influences on transportation controls and improvements. Through all of this behavioral research, it is important to identify and understand the day-to-day variability with factors of influence held constant in order to understand the level of confidence that can be placed in travel forecasts. Research is needed on whether current trip purpose definitions are appropriate for the new travel models or for studying the characteristics of today's travel behavior.

Trip Generation

Research is needed into the decision processes that produce travel behavior of households, persons in those households, and use of their vehicles or other transportation modes. Additional interest is in travel behavior on weekends and seasonal variations. Trip generation models need to be sensitive to the type and level of transportation services available and to the accessibility those services provide to activities in the urban area. The research should relate trip making to the activities desired by the household members and in particular should address the phenomenon of trip chaining to identify the characteristics of trips and travelers and other conditions that lead to trip chaining.

Trip Distribution

This research should examine the factors influencing destination choice. The research should examine the influence of available transportation services on destination selection. The criteria considered for destination selection should include combinations of travel costs and other factors that influence that decision. Research is especially needed on the destination selection process for non-home based trips.

Mode Choice
Research on the decision process in the choice of travel mode needs to address the influence of travel mode on trip chaining. The mode choice process for non-work trips is an area of particular research need. Mode choice in small and medium size areas should also be examined. There is particular interest in the factors and modeling of car pool formation and in forecasting HOV travel for non-work purposes. The influence on choice of mode from parking supply, availability, proximity to destinations, and cost should also be examined. Research is needed to develop procedures for forecasting park-and-ride lot demand. The choice research should develop procedures for pre-model estimation of choice sets. Research into the influence of safety and security on mode selection is another area needing study. Finally, better software is needed for developing nested logit mode choice models.

Traffic Assignment
Route selection criteria and decision processes should be investigated. Reliable procedures are needed for identifying queuing and bottlenecks, i.e., where, when, and why they occur and how to alleviate them. More work is needed to develop equilibrium, stochastic and dynamic assignment techniques, identifying the advantages, roles, and disadvantages of each for different classes of trips and different applications. The time dimensions of dynamic assignment applications need to be addressed. Trip chaining is an important consideration in this category as well.

Research is needed to develop better network analysis procedures and to improve on volume/density relationships. Procedures should be identified for standardizing network coding for highway and transit services. There is particular interest in improving the coding of alternative means of access to transit routes. New travel forecasting and air quality analyses will require computerized transportation networks that represent terrain and roadway geometrics and conditions. Stochastic network analysis is another area needing further development.

Other Travel Modeling
Research is needed to develop models for forecasting goods and freight movement and distribution of services and deliveries. These analyses should include effects of inter-city freight movements that terminate or traverse the urban area. The freight studies should also examine the effects of traffic access to intermodal (transshipment) terminals.

Research is needed to develop procedures for forecasting person travel originating outside the urban area that terminates, traverses, or is temporarily visiting within the urban area. Similar needs exist for better understanding and forecasting of travel using non-motorized modes and interaction using non-transport modes, e.g., telecommunications and televised shopping. Procedures should be developed for subarea analysis, including ability to analyze site or corridor conditions, consistent, integrated, and interfaced with regional models but with added detail and flexibility. Travel forecasting procedures should identify and work with the most appropriate level of detail, based on the information needed for decisions. These procedures are needed for evaluating alternatives and other major investment studies.

Simulation

Considerable interest and activity is currently focused on increased and enhanced use of simulation in the travel forecasting process. To further such approaches, research is needed to improve application of simulation procedures and develop computationally efficient algorithms for use in those procedures. For these new applications it is important to be aware of which simulation strategies work best in various settings and applications.

Air Quality

The travel models need to be improved to more accurately forecast motor vehicle emissions. This will require research to identify how vehicle characteristics and vehicle operation influence emissions. Research is also needed to develop techniques for forecasting the operating and emissions characteristics of vehicles available in each household and which vehicle will be used for each trip. The vehicle operating characteristics of each driver will also have to be identified. In addition, changes in fleet mix, vehicle characteristics, and fuel type will have to be forecast.

Research is also necessary to develop procedures for forecasting the conditions under which each vehicle will be operating. These include where cold starts occur, where the vehicles travel during engine warm-up, and the location and degree of vehicle acceleration and deceleration and grade handling. Improved information on the operating characteristics of trucks will also have to be identified. For the period until improved information on vehicles and operating characteristics is available, an acceptable procedure for post-processing traffic characteristics to obtain accurate emissions estimates should be developed.

Related to these research needs is the question of whether efforts to improve air quality models are necessary if there is a possibility of improving fuels and vehicles sufficiently to provide a technological "fix" for air quality problems. This demonstrates a need for special research to determine the likelihood that such technological innovation will occur and when. There is a need to look beyond the Clean Air Act requirements to what will be needed for air quality forecasting in future decades. In the meantime research is needed to improve emissions models now so current needs can be met with confidence until those needs are satisfied.

Software

The software for the new models should be developed with open architecture and standard interfaces to permit interchange of modules with alternative capabilities and for different applications. The new software should be developed according to guidelines and functional specifications that assure accomplishing the requirements of the models. The model structures themselves should be standardized. The software should be object-oriented and developed for application in a distributed computing environment.

The software package for the new models should include exterior modules and post processors to permit flexibility of use for different areas and different size problems. The programs should provide query and browse capabilities to aid and expedite analysis of applications, operations and problems. The software packages should include an array of utility programs for ease and efficient preparation and manipulation of input and output information. The package should include graphical presentation capabilities and quick reaction processors for use in responding to and providing support for decisions.

An information exchange should be established to organize and facilitate technical assistance and feedback on program usage. Software source code should be available to users for potential customization and modifications for unique situations and conditions. The descriptive material for algorithms should also be available to users.

Data

The workshop discussions identified particularly important or new data needs and recommendations for revisions of and research on data collection procedures.

Land Use
Information is needed on the effects of different urban designs on travel patterns.

Demographics
Data on the travel behavior of minority populations is needed to better determine the effects on travel in metropolitan areas where they are a major population segment.

Trip Generation
Data is needed on changes in travel behavior over time in order to modify forecasts to accommodate those changes. Information is needed on trip chaining as reflected in intermediate stops and short distance movement of vehicles in shopping districts. Daily and seasonal variation in travel is needed to better understand the variability of travel forecasts. Information on weekend travel patterns is also needed for better understanding the differences in traffic from typical weekday forecasts; this is particularly important for recreational travel but also for shopping trips. Information is also needed on travel patterns of non-residents, whether visitors or through trips.

Information on the effects of congestion and travel time reliability on choice of departure time is needed for better understanding congestion phenomena and estimating the spreading of peak travel periods. Data on trip attraction characteristics of special generators is needed to determine their effects on congestion. Finally the effects of telecommunications on travel attenuation should be determined.

Mode Choice
Data needed for these models includes the nature, amount, and variation of vehicle use within households as correlated to the characteristics of those households. Allocation of available vehicles among trips and drivers within the household should be determined. Conditions and characteristics that affect ride sharing should be identified. Vehicle occupancy for non-work travel is especially needed. Travel patterns by bicycles and as pedestrians should be identified along with the characteristics that influence decisions to use those

modes. Data on telecommunications, telecommuting and facsimile communications in lieu of travel should be obtained with the conditions and characteristics of those choices.

Networks
Information is needed on the distribution of non-resident and other inter-urban traffic on transportation networks. Improved traffic count data is needed for identifying current problems and for validating travel model development. The relationships between transportation system conditions and changes and land use patterns and changes should be identified. Measures of speed variability and acceleration and deceleration need to be improved for application in network coding and for determining emission characteristics from traffic assignments on networks. This information should include better identification of relationships between speed and traffic volume.

Other Data Needs
Better information on emission model inputs is needed, such as emission rates for cold starts, acceleration at varying rates, hill climbing and hot soaks. The percent of vehicle time spent in each operating mode is also needed. Information on commodity flows and transport characteristics is another need and should include driver work rules that influence those characteristics and driver logs for actual itineraries.

Data Preparation
Guidelines are needed for collection of data to serve the travel models. These guidelines should establish standards, including the expectations or requirements for data to be used by the models. Research is needed to determine the critical data elements and the needed level of detail of data for the models. It is also important to collect data in a continuing process in order to identify trends and other changes in key factors that affect travel behavior. The data collected must be in sufficient detail and accuracy for validating the models. The characteristics needed for the data to be adequate for validation should be established by the research.

It is important to begin now to establish the characteristics and criteria for data needed for models so that planning and acquisition of the data can proceed in a timely manner so that it will be ready when needed for validation. It is especially important that the requirements for data for the new models be established and that those requirements are available to planning agencies so that data collection efforts currently being planned are accurately designed to provide data adequate for the new models.

Another criterion for data acquisition is to determine what different data is required for levels of analysis. Policy studies for example may be able to use much more aggregated data as long as it is regionally representative, whereas corridor or other subarea analysis must have localized and more precise information. Standards should be established for data to be used by the models so that data collectors and users know what to collect and why and how that information will be used in the models. The standardization should extend to data format and data collection design to assure that the necessary and proper data is being obtained.

In designing the models and efforts to collect data for them, consideration should be given to maximizing the use of existing databases. Where possible the models should be adjusted if feasible in order to accommodate using existing databases, such as the Census CTPP for example. This does not mean that the models should be "hammered" to use available data but that due consideration for efficiency and economy should be exercised in specifying the models and their data needs. Probably the most important of the databases to consider in establishing the data needs of models are those produced by various geographic information systems. These powerful databases are a key to providing the detail required by the new models.

Procedures

Data collection efforts should be based on statistical experiment designs for the actual purpose and use intended. What those designs might be for different uses and conditions should be established according to the model needs as part of the model design process. This may require research into the possible approaches and strategies for experiment analysis and survey designs that will best fit the requirements of the models. The survey design and model development process should also examine techniques to merge synthetic and survey data since the synthetic data is potentially a strong attribute of some of the newly developed models. The survey designs will identify the appropriate sample sizes for surveys, and special attention should be paid to distribution characteristics and behavior of non-work trips. Another important consideration in data collection for improved and new models is trends and other changes over time. This has been addressed in recent longitudinal panel surveys that revisit samples periodically, and this approach should be considered for application in the data collection for the new models.

Concern was expressed at the conference about the resource requirements, especially the amount and quality of data needed for the TRANSIMS model or any other simulation model. It is important to consider the staffing and funding implications of any new model under development. Those have obvious and potentially onerous implications for agencies preparing to use the new models. These concerns add support to the recommendation that the model development activities endeavor to maximize use of existing data sources rather than requiring wholly new databases. Data sources that should be more strongly considered for exploitation are the Census CTPP and the NPTS. Another resource is SHRP information on surveys and syntheses of practice. The problems with detail, accuracy and timely availability of these sources should be addressed in order to increase their utility for the new models. These databases offer especially significant potential as the empirical basis for generation of synthetic populations and activities. Those synthetic databases will rely on periodic updates from the CTPP and the NPTS that serve as a real and consistent foundation and to identify changes to be incorporated in the travel models.

Other issues related to data included concern about the privacy restrictions on credit card data that may obviate its utility as a source for the new travel models. A specific recommendation is for a data collection process to replace or redevelop the HPMS. There were recommendations for improvement in and expanded use of geographic information systems. The GIS database could serve as the framework for the new travel models. Another recommendation was for improved data structures such as using dynamic segmentation in the manner employed for some GIS.

Research

There is a need for research on survey methods, including alternative types of surveys, sample sizes, survey designs, etc., to improve the efficiency of data acquisition and data processing. This research should include examination of sampling procedures and design of survey instruments. The research should investigate and identify appropriate experiment designs for transportation analysis and forecasting. The utility of stated preference surveys is a study of prime interest. The survey designs should be especially oriented to obtain information for short trips, which are often lost in existing survey techniques. Time series data on activities and travel should be obtained to aid in forecasting more accurately.

Land Use

Considerable research is needed on land use and development forecasting procedures to improve the information available for urban planning and to provide better information required to improve travel forecasts. This should include research on the effects of development patterns on activity patterns generated in the travel models. Information for both near-term and longer period developments needs to be improved. A key concern of this conference was to assure that "feedback" occurs between transportation level of service and development allocation so that a reasonable equilibrium is established between transportation service and land use. The land use and travel models must be carefully integrated so that the variability of spatial activity distribution can influence the activity decisions and behavior in the travel models.

An important aspect of both activity and development forecasting is accurately forecasting demographic and economic conditions that affect both development and travel behavior. Research is needed to better understand the social and economic factors that influence development and travel. Among the factors generally recognized as influential but whose forecasting requires further research are size of households, age and gender composition, life-style and place in life cycle, family situation (i.e., single parentage), the roles of household members, and how activities are allocated in the households. All of these influence choice of location of residence, workplace, and other activities as well as travel behavior. There is also need for research into the methods of demographic and economic forecasting including econometric procedures.

There is a need for research on land use forecasting models and related procedures. Paramount in this research would be improving prediction of locations of residential, industrial, other workplaces, and other activities. Interest is in better understanding and replicating the decision process and participants in that process and their respective roles. The role of real estate prices is a key factor identified for consideration in this research. Temporal dynamics, the change in factors, conditions and their influences on development decision processes should also be addressed. The new land use and development location models forthcoming from this research must be behaviorally oriented and related to activities in order to be properly integrated with and produce information needed for the travel models. For the newly emerging travel models, it is important that research of location decisions be oriented to understanding activity locations rather than merely land use or development, recognizing that the activity type and characteristics dictate locations and are the principal influences on travel behavior.

The research leading to development of the activity and development location models should consider relationships between the influence of the marketplace and developer plans. The interactive relationship of urban form and design with travel behavior should also be studied. Models to forecast detailed or micro-scale land use in relation to small area transportation services should be considered as well. The longer term evolution of urban development and land use patterns is another appropriate aspect for study. Finally a simple land use model for application in smaller or less complex urban settings would be useful.

Sample Populations

There are several issues related to demographic forecasting that are recommended for research. One of these should address whether creating synthetic populations from samples yields an accurately representative mix of the true diversity of population characteristics. Another concern is the examination of the continual changes in the behavior of individual persons, households and neighborhoods. These characteristics need to be included in the forecasting process if it is to be accurate.

Model development research should pay careful attention to activity generation and forecasting, in addition to the conventional emphasis on the travel aspects of the process. Both the activity and travel models must be based on behavior observed and developed in a well designed empirical process. Concepts such as development and change of habits and adaptation to changes of conditions that influence activity and travel decisions should be carefully researched.

Training

The recommendations on training reveal that inadequate attention has been given to these areas during the past decade. The needs and resulting recommendations fell generally into two categories: target groups for training and training needs.

Target Groups for Training

Training is needed for all levels of professional and technical staff involved in transportation and environmental planning who must use models to prepare travel forecasts, for policy/decision makers who use travel forecasts for decisions, and for lay persons who are stakeholders affected by the forecasts. Special training is needed for persons who are not computer-literate. A program of training should be designed for entry, mid- and advanced practitioners, including model users from MPOs, state DOTs, cities, environmental agencies and other organizations. Of particular importance is the need for this program to differentiate between the training needs of the large and small MPOs.

The need for intensive professional training programs spanning several months was identified, but consideration of the staff time constraints was also cited. Training programs should provide continuing professional education with certification and credit. A particular need is for short duration continuing education to help keep practitioners up-to-date.

Curricula for university transportation planning courses should be developed. Tuition assistance, fellowships, and internships should be provided to encourage undergraduates to study specialties related to transportation planning.

Training Needs and Programs

A wide range of training topics was identified. These include topics that should be covered during the next five years and others necessary for using model improvements being developed in the longer term. The training should begin with an assessment of current training activities in order to improve and complement them rather than duplicating them. That information would in itself be valuable to practitioners. Training courses should cover both theory and practice, and should include case studies to illustrate implementation in different situations according to need.

Short-term training needs include appropriate practices for use of the existing models, methods and practices from outside the United States, how to use and implement quick-fixes, how to perform major investment analyses, how to calibrate distribution models, and how to implement the requirements of ISTEA with existing tools. Training should be provided for integrating travel models with GIS, translating simple concepts into computer code, guidance on software selection and how to install new software for existing model program packages. The training should address the use and application of model forecasts, not just how to use the computer programs. The latter is a necessary part of deployment.

Training that should be considered for longer-term needs includes how to transition from existing models to those being developed in the TRANSIMS project, how the new-models can be used in the transportation decision process, how to forecast the new variables required by the models, and training in new data requirements, collection and storage procedures.

Training programs should be designed to accommodate the differences between areas and agencies and between appropriate practice and best practice. Such programs might include in-house training during implementation of new procedures or software, one-on-one training with follow-up as needed, and focused training with software vendors. The Florida DOT and New York Metropolitan Transportation Commission programs are considered good examples of effective training.

The program should include extensive use of computer based training and video training materials. These programs should employ newly developed multi-media techniques and should include hands-on guidance using case studies and demonstration projects. It is important for training to be carefully linked to the research and development for improved models.

It was recommended that there be strong federal leadership in the development and deployment of training programs. This should include use of triennial reviews to determine MPO practices and needs and the use of project grants for project specific training. The various training programs should be concurrently available to include all interested participants but avoid a long lag time in reaching all areas.

The University Transportation Research Centers could be used to develop and deploy the training programs. Universities would provide hands-on training for software. The training should be provided at outside universities and should include periodic in-service and mid-career activities as well as for entry levels. Training "circuit riders" should be available to visit MPOs and provide on-site area and agency specific assistance. All trainers should be certified for the specific course material/training they are providing. Consultants should play an active role in providing training although there was concern over the loss of feedback and control over the program when contractors are used. It was recommended that training mandates be supported by dedicating part of planning program budgets. Possible approaches are to use university transportation research centers, for MPOs to fund fellowships for work on their staffs, or for their staffs to be training at universities or through other organized efforts.

Program Guidance

General

A strategic plan for travel model improvement, development, and related efforts should be prepared to guide the process. New procedures from any of the tracks of this program should be recommended but should not be required for use in the planning process.

Communication

There was concern about the need for more communication with the Los Alamos National Laboratory regarding the TRANSIMS project. Both the user and the research communities need to be working more closely with the Los Alamos team to communicate their needs and ideas and to provide guidance as requested by the team and the sponsors. It was suggested that an avenue of communication could be established by Los Alamos hiring a person experienced in travel forecasting as currently practiced.

Communication on the content and status of the Program is needed for support, participation and acceptance of the ultimate products. To accomplish this, special communication channels should be established to facilitate sharing information on and the status of the TRANSIMS project. The media used could be video conferencing, video taping, or newsletters. Interactive remote transmissions would be helpful for all parties, explaining things to the audience and providing guidance to the researchers. The communication must be carefully designed to clearly translate complex new concepts for understanding by practitioners as well as constituents of the planning and forecasting process.

Increased communication among MPOs should be encouraged to facilitate sharing of problems and solutions. This can be accomplished using Internet or other bulletin board services. Communication about model development work in other countries is an important consideration for the Program as well.

Funding

A need for additional funding was expressed to broaden the research in universities and other research centers to complement the TRANSIMS efforts. One possibility would be stronger financial involvement of FTA, NSF and state DOTs. The increased funding is needed for activities in areas other than the TRANSIMS work in Track C, particularly for training and other dissemination of new and improved models. Funding of case studies and other demonstrations should be provided to stimulate developing innovative practice. Some of that funding should be provided for research by and for MPOs.

Resources
Concern was expressed about the amount of resources needed to develop and use the new travel models. In particular the staffing and computing requirements and related funding demands seem to be beyond current funding availability. Special attention is needed to alleviate those problems. This underscores the need for strong training efforts to develop new and improved staff resources.

Peer Review
It was strongly recommended that a peer review process be established for all aspects of the Travel Model Improvement Program. Peer groups should be formed to review proposals and project progress, results, and products. These groups would provide guidance, support, and a framework for judging the reasonability of model structures and factors incorporated in the models. The review groups should be composed of professionals experienced in the several disciplines that influence or are affected by travel forecasts, including academicians, consultants, other practitioners, and vendors.

Professional Participation
Comments in the workshops included the need for Program activities to be open to professional review and comment in addition to the peer review process. Establishing an association of transportation professionals that would recommend or endorse education and training programs was another recommendation. Such an umbrella association could encourage forming regional transportation planner practitioner groups. Working more closely with ITE, ASCE, and AASHTO, the existing professional organizations.

Research Options
These options are more general recommendations for research than specific items mentioned elsewhere in this document. Research should be conducted in Track C on other new modeling approaches as options to TRANSIMS. Research conducted in Europe and elsewhere outside this country should be considered for possible contributions to this program. A dynamic systems framework should be explored for domestic travel model research. A university research program funded by small three-year grants should be established for possible contributions to this program.

Transferability
Transferability of research findings among metropolitan areas should be a major concern of the Program. To accomplish this, the research should identify how procedures can be tailored to suit the particular needs of different locations and decisions.

Early Products
Early access should be provided to interim products of the TRANSIMS project, particularly for advances usable in air quality assessments. The U.S. DOT should establish an information clearinghouse that would facilitate dissemination of information on the Program and distribution of Program products and other procedures potentially useful to the transportation planning community.

Deployment
Concerns were expressed about how to deploy the new and improved models. An issue in this regard is the need to assure that descriptions of the Program do not establish unsatisfiable expectations. Implementing results of the Program, whether improved or new models, must consider the problems and needs of practitioners as they transition from previous procedures. The transition process should be carefully conceived, led and monitored by the U.S. DOT to establish guidelines and standards for improved procedures without disruptive mandates.

Documentation
The model documentation, particularly for TRANSIMS, must be understandable to the Program audiences, policy/decision makers, the general public and other affected parties as well as to practitioners using the models. To accomplish this, one page summaries of various existing as well as new techniques should be prepared. Documentation of recommended modeling practices should include alternative strategies for different types and levels of usage, particularly reflecting the varying needs of different MPOs.

Dissemination
A variety of methods should be used to disseminate current and future information. As with the training program, a strong federal role was encouraged. A federal clearinghouse for information should be established and made accessible through different media such as Internet, electronic bulletin boards, and regular mailings. A resource library of models and data sets needs to be established.

Results of the Program should be made available continually for practitioners and affected audiences as soon as the Program and other products are tested for validity and available. These results would include periodic enhancements and refinements as they occur and results of case studies and demonstrations. It may be appropriate to have different dissemination procedures or media for various groups, depending on the level and nature of their involvement in the Program and the planning process and on the level of modeling they employ. The Planning Methods Applications Conference is a medium for timely dissemination that should be continued.

Information considered important for timely dissemination includes recommended modeling practices and analytical techniques, data collection procedures, new products as they are available, the results of case studies and demonstrations, and progress of development of TRANSIMS. Particular attention should be dedicated to describing which techniques are most appropriate for different locations and situations and how various techniques can be adapted to suit particular conditions.

The dissemination of existing model improvements and analysis techniques should begin as quickly as possible. A catalog of available tools should be developed complete with summaries of methods and products, contact names and phone numbers. Guidance should be provided on standards of good and best practices in the form of manuals that codify existing practices and available model improvements and that include flow charts for each technique or application. "How To" manuals on modeling, surveys, data collection/

storage, and transit, external/non-resident, and special generator travel were also noted as needs. Information which compares existing and new software products, and better, more user friendly software documentation are also immediate needs.
Sample RFPs for various study types should be made available, as should timely notification of conferences and distribution of conference results.

Regular updates on TRANSIMS and other application test cases should be provided. Notice of new data requirements, collection and storage procedures should be given at the earliest possible date.

A partnership between the federal agencies, state DOTs and MPOs would assure that the most current information is available to all interested persons, particularly individuals involved in related fields. MPOs should establish an information exchange to assist in the distribution of materials and practices.

Presentation Abstracts

Activity-Based Modeling and Policy Analysis

by Clarisse V. Lula, Research Decision Consultants, Inc.

This project is designed to conduct activity-based research for the Metropolitan Washington Council of Governments (MWCOG). The goal of the project is to develop a regional policy model which will be used to assess the ways in which an individual's travel behavior changes in response to the introduction of regional transportation control measures (TCMs). This activity mobility system (AMOS) is a microsimulation approach in which changes in individual's travel behavior are based on treating travel as a demand derived from the distribution of his or her daily schedule of activities in time and space. As such, the approach provides the structure for examining the impact of policies on a broad range of behavioral factors including changes in time-of-day of travel, the sequence of activities and trips, trip generation, trip chaining, destination choice and mode choice.

The prototype implementation of the activity-based approach (AMOS) for the MWCOG region is formulated as a "regional policy model" that estimates impacts on travel indices and emissions in the short- and mid-term. The system is a dynamic system that will allow behaviors to change gradually over time and allow for behavioral inertias. Individuals' potential response to changes in their travel environment will be examined using a survey conducted in the region that has been designed to obtain both baseline activity-trip patterns and people's stated preferences in response to potential changes in their travel environment. The sample survey will be weighted to reflect the socioeconomic and demographic profile of the region. Quantitative changes in behavior will be derived using neural network models, and encapsulated in a TCM policy response generator that indicates an individual's initial change in his or her travel pattern in response to the introduction of TCMs. As well, people's preferences for ancillary modifications to their trip patterns will be further refined based on the survey results and checked against a rule-base for consistency with existing constraints on their schedules. The model system is designed to search for an "acceptable" or "satisfactory" new activity-travel pattern for the individual through a trial and error procedure that simulates people's learning behavior. The resulting changes in travel behavior are either accepted or rejected based on various time-use utility functions.

The activity-based modeling components have been designed and tested on a preliminary basis. The model has been initiated by MWCOG and is being integrated into its existing system. The AMOS survey has been designed and will be fielded in the fall of 1994. It is expected that the neural network modeling will begin in late 1994. Implementation and testing of the AMOS model system will begin in early 1995 using AMOS' 1994 survey as well as MWCOG's 1994 household travel survey.

Identification of Short-Term Travel Model Improvements

by Thomas Rossi, Cambridge Systematics, Inc.

The purpose of this project was to identify existing methods and applications to improve current urban travel models in the short term. In general, the identified improvements are methods and procedures that have been implemented in some urban areas, although many of these improvements may not be well-known.

This project was performed by Cambridge Systematics, Inc. and Barton-Aschman Associates. In addition to the experience of the project consultants, other travel demand modeling experts and practitioners in the United States were canvassed to identify existing model improvements. Those interviewed included MPO and state DOT staff members, consultants, academic researchers, and U.S. DOT officials. The findings are documented in the report "Short Term Travel Model Improvements," dated August 1994. This report may be used as a reference for identifying potential model improvements and as a guide to identifying model improvements for further documentation.

The project identified 12 general categories of model improvements. These are documented in the report as follows:

Travel Surveys
Methods for conducting various types of travel model related surveys and survey processing issues such as expansion and geocoding are reviewed.

Modeling Non-Motorized Travel
Most modeling processes in use do not incorporate pedestrian or bicycle trips. Because mode choice can be affected by the types of variables included in the model, most new models are now incorporating these options both as primary travel modes and for transit access. The review of modeling procedures for non-motorized trips also included a review of methods to incorporate measures of the pedestrian environment into the travel models system.

Land Use Allocation Models
The most widely used land use allocation models were identified. The data needs, necessary resources, advantages and disadvantages, and alternatives to using a land use model were prepared.

Dynamic Assignment
Dynamic traffic assignments are not widely used in models employed by most MPOs although there is available software. The uses, advantages, and disadvantages of dynamic traffic assignment, as well as appropriate situations for use and available software, are identified.

Air Quality Analysis Methods
Methods currently used to predict trips by vehicle operating mode (i.e., hot/cold start) and to adjust speeds both during and after traffic assignment are reviewed. The necessary resources to implement these procedures and the drawbacks are discussed.

Modeling Trip Chaining Behavior
No current procedures to account for trip chaining were identified. Research into methods to model trip chains and how to incorporate these into the travel modeling process, however, are reviewed.

Mode Choice Modeling Improvements
Numerous mode choice issues including incremental logit modeling, HOV modeling, transit captivity, transit transfers, integration of mode choice with other steps in the model process, transferring models between different areas, use of Monte Carlo simulation, and modeling toll facilities are identified and reviewed.

Parking Analysis Procedure
Parking is an issue that is not handled effectively, if at all, in current travel models. Methods to reallocate trip ends to parking locations rather than destinations, to analyze the effect of time-of-day on parking and to model parking costs are discussed.

Time-of-Day Models
Most areas currently factor daily trip tables to reflect specific times or time periods. Methods to factor daily trip tables to peak periods, to reduce peak hour trip tables to reflect network capacity constraints, to model peak spreading, and to model time-of-day prior to trip distribution are identified and discussed.

Trip Table Estimation
Available procedures to estimate trip tables from data such as traffic counts, the available software and discussion of necessary resources are presented.

Modeling of Trip Generation Input Variables
Modeling trip generation inputs such as auto ownership, employment and household characteristics using existing data are reviewed. Most of the available models are based on either logit formulas or regression equations and represent a kind of choice model. Household simulation, in which household decisions such as location, car ownership and household size are estimated, is an area that is relatively new, but is being pursued in several areas.

Trip Assignment Issues
Methods to code transit access using GIS, analyze toll highways, and a discussion of instability issues in saturated networks are included.

Travel Survey Manual Update

by Thomas Rossi, Cambridge Systematics, Inc.

The need for this work was identified subsequent to completion of the report "Short Term Travel Model Improvements," dated August 1994. The last travel survey manual was prepared 20 years ago. Since then, a number of new methods, types of surveys, and analysis procedures have been developed. Travel modeling procedures have advanced, and technological improvements have made conducting surveys and analyzing data more efficient. The objective of the project is to develop a new manual of travel survey techniques. This manual will be based on the advances made during the past two decades and will draw upon the experience of a number of recent surveys conducted at various locations in the United States. Particular attention will be paid to the needs and uses of travel survey data, especially emerging demands on surveys due to new transportation planning requirements, air quality analysis needs, and ongoing travel model improvements.

The manual will cover a variety of survey types, including:

- Household travel,
- Transit on-board,
- Vehicle intercept,
- Commercial vehicle/freight,
- Workplace/establishment/visitor,
- Panel,
- Stated preference,
- Special generator, and
- Parking.

Detailed descriptions on how to conduct the various types of surveys will be provided. The manual will include information on survey administration, survey design, sampling, data collection procedures, pre-testing, data entry, verification, and data analysis. The issue of geocoding will be discussed, and the purpose, methods, and data sources involved will be described. Additionally, the manual will include a listing of recent survey information including contact names, survey forms, and requests for proposals.

The revised manual is expected to be completed by January 1995.

The Effects of Land Use and Travel Demand Management Strategies on Commuting Behavior

by John Suhrbier and Susan Moses, presentation by Thomas Rossi, Cambridge Systematics, Inc.

There is considerable interest in the effects of urban design and land use characteristics on individual transportation choices. The underlying assumption is that these employment site characteristics have an important influence on a person's willingness to commute by transit, ridesharing, bicycling, walking, or modes other than drive alone. Furthermore, the selection of transportation demand management (TDM) strategies that an employer may choose to implement should be a function of surrounding site characteristics, and the combination of site characteristics and TDM strategies can have a positive interactive effect in influencing an employee's choice of commute travel mode.

For this project, an integrated database of land use characteristics and TDM strategies was developed for specific locations in Los Angeles County. The integrated database was constructed by adding land use and site information to the "Regulation XV" data set of the South Coast Air Quality Management District (SCAQMD). The SCAQMD data set includes information about aggregate employee travel characteristics, and the incentive programs offered by employers. This integrated data set was then analyzed to explore the interactions that may exist between TDM programs, land use, urban design characteristics, and employee mode choice. The primary objective was to develop conclusions about the combined impacts of land use and travel demand management strategies on employee travel behavior.

The technique of Principal Components analysis was used to group land use variables into composite variables representing site characteristics. Five specific land use/urban design characteristics were defined: sites perceived as safe, aesthetically pleasing urban sites, sites with a mix of land uses, sites with a diversity of convenience-oriented services, and sites with good accessibility to services. Standard analysis of variance techniques were then used to understand the effects of these composite land use variables and TDM programs on travel behavior.

It was found in the study that financial incentives are the most effective TDM strategy for reducing the drive alone mode share. At sites where financial incentives were offered, the drive alone share decreased by 6.4 percent from the time that the Regulation XV programs were implemented, compared with a 1.7 percent decrease at sites without financial incentives. For each land use/urban design category, financial incentives accounted for the majority of the reduction in the drive alone mode share.

The analysis revealed that the effectiveness of TDM programs did increase in areas with supportive land use and urban design characteristics. The data revealed that when financial incentives are present, the greatest reduction in the drive alone share is realized in areas with aesthetically pleasing urban character. The drive alone mode share at these sites is at least three percent less than at sites exhibiting any other land use characteristics analyzed. This appears to be the result of the availability of alternative modes and the quality of the environment. Sites with a preponderance of convenience-oriented services realized the next greatest reduction in the drive alone share, followed by sites with good access to services, sites with the perception of safety, and sites with a mix of land uses.

TDM strategies have a larger influence on reducing the drive alone mode share than do land use characteristics when each is considered individually. The findings, however, further revealed that there is a positive cumulative impact on increasing average vehicle ridership (AVR) and reducing drive alone mode share when both financial incentives and one of the five land use characteristics analyzed are present. The impacts are not linear in that the cumulative effect is less than the sum of the parts.

The TDM programs examined are most beneficial in increasing the level of ridesharing. This increase, however, results not only in a decrease in the drive alone mode, but also in a decrease in transit, walking, and bicycling trips. Transit and walk/bike mode shares are highest at sites with supportive land use and urban design characteristics. This further indicates that mode choice is influenced by both land use characteristics and the availability of TDMs.

Employer-provided transportation assistance programs have a small but statistically significant impact on reducing the drive alone modal share (-5.3 percent) and increasing the AVR (from 1.223 to 1.285) at sites having a mix of convenience-oriented services. Assistance programs alone were not found to have a significant impact on either the drive alone share or AVR at sites with other land use characteristics.

While the average level of walking and biking over all the sites surveyed was 5.4 percent, selected sites had post-implementation mode shares that were two and one-half times this level. These sites were characterized by land use and urban design characteristics that encourage alternative modes of travel for the work trip. Furthermore, these sites offered financial incentives in the form of walk and bicycle subsidies that were well above the averages for all sites analyzed.

Improved Network Models: Multicriteria Traffic Assignment, T2

by Robert B. Dial, Ph.D., U.S. DOT/Volpe Center

T2 is an equilibrium traffic assignment model that solves the following problem: given a network whose arcs have two disutilities, call them cost and time:

c_e = cost on arc e

$T_e(x_e)$ = time on arc e, a function of total flow on the arc

x_e = total flow on the arc e,

assume each trip chooses a path p that minimizes its particular perceived generalized cost $g_p(\alpha)$, where

$g_p = c_p + \alpha t_p$

$c_p = c_e =$ the out-of-pocket cost of the path

$t_p = t_e(x_e) =$ the time on the path

α = the "value of time,"

and the value-of-time parameter α is a random variable, with arbitrary given probability density that may vary by o-d pair. Now, given an o-d matrix of total trips, the problem is to find an equilibrium traffic flow, which has every trip using a path that minimizes its particular perceived $g_p(\alpha)$.

T2 generalizes conventional traffic assignment by relaxing the value-of-time parameter in the generalized-cost function from a constant to a random variable, with an arbitrary probability density function. Its application potential spans a wide domain of currently difficult problems in traffic, highway and transit planning - including simultaneous mode/route choice, congestion pricing and parking policies.

A model was defined, its mathematical formulation cast, and solution algorithms designed. The algorithm is very space efficient: it can find the *total* arc flows at equilibrium without having to save individual arc flow for each value-of-time α. No real information is lost, since these latter flows are not unique. Hence, T2 can run on networks as large as those for conventional traffic assignment.

A prototype code running under TransCad demonstrates the model's sensitivities on toy networks. By the end of the year, a "production code," will be available along with statistics describing its performance on a PC solving networks having up to 100,000 nodes.

Planned future work will increase the number of criteria from two to three, and implement the model as a dynamic assignment.

These results appear in the technical paper:

Multicriteria Equilibrium Traffic Assignment: Basic Theory and Elementary Algorithms, Part I, T2: The Bicriteria Model

Equilibrium Conditions in Land Use and Travel Forecasting

by Stephen H. Putman, Ph.D., S.H. Putman Associates, presentation by Frederick Ducca, Ph.D.

The consistency requirements of both ISTEA and CAAA explicitly recognize the inter-relatedness of transportation and land use and assume the need for a proper representation of those linkages between land use and transportation phenomena which can significantly alter the outcomes of long-range forecasts. Much of the discussion in transportation and land use planning practice, when it does acknowledge the potential importance of these interactions, addresses the issue in terms of requirements for equilibrium solutions. What is not known is: a) Whether such solutions are computationally practical; b) Whether they will differ significantly from solutions achieved in the absence of formal linkages between the two forecasting activities; and c) Whether they will actually be better forecasts of the future land use and transportation reality.

In order to address the above issues and improve its current forecasting process, the Metropolitan Service District (METRO), in cooperation with the Oregon Department of Transportation and the Federal Highway Administration, has undertaken to perform a comprehensive series of tests to determine the criticality of the consistency issue with particular reference to the land use feedback to transportation models, identify conditions under which it must be addressed, and make technical recommendations for methods to modify existing procedures. It is expected that the results of this study will have implications not only for METRO but nationally for other users of the travel demand process.

Following extensive reexamination of model structures and subsequent model recalibrations, four land use/ transportation model sensitivity experiments have been completed for a single forecast period 1990-1995. For all the experiments, the EMPAL/DRAM employment and household forecasts were made at a 100 zone level of geographic detail. Two levels of geographic detail were tested for the METRO travel demand models and trip assignment procedures. The *sketch* level uses an aggregated network specification, and both travel demand and trip assignment are estimated for a network with 100 load nodes exactly corresponding to the EMPAL/DRAM zone centroids. The *detailed* network specification has 1189 load nodes and 18,960 one-way links. When running experiments for the detailed network, the EMPAL/DRAM forecasts are disaggregated from 100 zones to 1189 traffic analysis zones. The output of METRO's travel demand and trip assignment models (i.e., a 1189x1189 travel time matrix) is collapsed to a 100x100 travel time matrix for use in EMPAL and DRAM.

For both levels of network detail, two configurations of travel demand/trip assignment (inner) iterations and linked land use/transportation (outer) iterations were used. The first configuration uses a single travel demand/trip assignment iteration within each linked land use/transportation model iteration. The second configuration uses three travel demand/trip assignment iterations within each linked land use/transportation model iteration. The three inner iterations begin with an estimation of travel demand based on travel times from the previous outer iteration and the current EMPAL/DRAM forecast of employment/household location. The estimated travel demand is used as an input to the trip assignment procedure, and the resulting travel times are used to re-estimate travel demand. The final set of travel times is based on an assignment of the trips produced by the third travel demand estimation.

For the sketch level of network detail, both configurations of the land use/transportation model converged to the *same* solution in three outer iterations. Each inner iteration required approximately 14 trip assignment iterations. At the system wide equilibrium solution, the user equilibrium (UE) objective function for trip assignment is minimized and household consumer surplus is maximized. The solution trajectory for the model with three inner iterations is smoother than the solution trajectory for the model with one inner iteration, but the rate of convergence is essentially identical.

For the detailed network, both configurations of the land use/transportation model system converged to the same solution in three outer iterations. Each inner iteration required approximately 8 trip assignment iterations. At the equilibrium solution, the UE objective function is minimized and household consumer surplus is maximized.

For the sketch network specification, approximately 20 percent of trips are intrazonal and are not assigned to the transportation network. For the detailed network specification, only 3 percent of trips are intrazonal. At the equilibrium solution for the sketch network, total VHT equals 130,123 and total VMT equals 3,897,550 with average link speed equal to 29.95 mph. At the equilibrium solution for the detailed network, total VHT equals 172,394 and total VMT equals 4,947, 882 with an average link speed of 28.7 mph. As a result, household consumer surplus is higher when the sketch network specification is used.

These tests show that there is a significant difference in the outputs, of both land use and transportation variables, from the equilibrium solution procedure as compared to the traditional linear four-step procedure. The differences are present for both levels of geographic detail and for various levels of network congestion. An auxiliary set of tests done with data for the Los Angeles region yielded similar results.

In the next phase of the project, these tests will be extended to longer time horizons and will be examined more closely for the exact sources of the differences which have been detected between the different model system configuration results.

Travel Model Improvement Program: TRANSIMS Presentation

[This is an edited transcript of the August 16, 1994 conference presentation on TRANSIMS by Los Alamos National Laboratory staff.]

Introductory Remarks

by Darrell Morgeson, Ph.D., Los Alamos National Laboratory

The presentation this morning will explain the technical activity and direction of TRANSIMS. We will describe the algorithms and methodology. As we go through that, we will point out places Tracks B and C might merge or complement one another, both in the near and long term. We will also describe how the systems architecture and formulations may accommodate and integrate with the research that others have done and are doing.

Fred Ducca mentioned that we began working on TRANSIMS about two years ago. A New Mexico organization called the Alliance for Transportation Research seeks to draw out the particular strengths of the laboratories and universities in the state, and in this case they apply to transportation issues. Los Alamos National Laboratory has been working with simulations for about ten years. Most of those have been for the Department of Defense, and a lot of our methodologies draw from that. Early on we developed an interest in environmental issues, driven largely by the Clean Air Act. The work reported here is requirement and policy driven, starting with the questions of what is the computational framework which will satisfy those issues. This work was not restricted to use the computing power on your desktop today, personal computers and the current generation of computational technology. The work is aimed at machines that will be affordable and effective for you by the end of the century. If you just trace or graph how computing power and performance is going relative to the price, you will realize that some staggering things are going to be on your desktop.

The TRANSIMS team personnel have done a lot of reading to learn the four-step method and other practices used today. One piece that I read said, "under the assumption that you cannot compute every household." That is not the assumption of our work. Our assumption is the opposite of that. TRANSIMS computes every household and every individual. We, and others internationally, have shown that can be done. But computing at that level in large metropolitan areas introduces a new issue of system science into the process. Simulating at this level of detail requires and generates a tremendous amount of data. In Albuquerque, for example, a ten minute simulation of traffic along the interstate highway, including about thirty or forty thousand vehicles, required about 10 kilo bites of data. That is about equal to two or three versions of the Encyclopedia Britannica. For a twenty-four hour period, not only does understanding and interpreting the data become a problem, but storing it as well. Our project will have to develop ways to look at these large volumes of data and pick out patterns that are of interest and importance. The systems science issues are very important here if you expect to compute at that level. We have done a lot of work in Mexico City identifying the sources of emissions, how complex air chemistry and air mixing models go together to represent the Mexico City air pollution. We have measured that air over the last eight years and perfected those models so that they are probably among the best predictors available of what happens to the environment due to heavy sources of pollution.

To produce better information related to environmental issues, these models require a certain level of detail and microsimulation. Averages of required data are not sufficient. With these models you cannot use averages. You cannot mix everything together and get an average speed on roadway segments to input to the environmental models that we are examining. Acceleration, engine temperature and cold starts make a difference. If they make a difference at a causal level, they must be modeled in order to accurately predict their effects. TRANSIMS tracks every car, every driver, every stoplight, acceleration, deceleration, braking and turning. We also use information on roadway grade. All of that is done for one second intervals, and that feeds the environmental model.

Given that you are going to simulate in that detail, the question is how do you know what is on the roadway. How do you treat demand? You do not just throw all the vehicles out there and have them interact. So we produce trip plans. This is a very simple and straightforward concept. In the model every individual has a set of activities that he or she wants to engage in. This is done on a household level. Those activities and their destinations, together with data on the behavior of individual people in the household, their income, and various demographic variables, feed into the trip planner. The planner determines what particular roadway segments, bus segments and rail segments that each individual will use. Implicit in the trip planner are intermodal decisions. We account for intermodal trips inside the trip planner. For the entire population for the entire twenty-four hours, we account for each trip decision implicitly. Drivers and households resolve conflicts among themselves as they do in the real world. They decide to leave earlier in order to avoid congestion. They decide which route to take and/or which mode and so forth.

The information that feeds the trip planner is obtained from demographic and land use planning models. The demand is estimated for people and individuals, and for commodities and freight. Once this computation machinery is integrated, it doesn't care whether it is moving a box or a person. It simply has identified the demand to get from Point A to Points B, C and D throughout the day. This process requires a lot of data, and we have identified some good sources of data.

Over the last 20 years, the IRS and financial institutions have adapted to the use of credit cards in lieu of green stuff in our billfolds. The information they have on each of us is beginning to be scary. Some of that information is available and usable. The story I use to illustrate this is that when we first bought a horse three years ago, I bought my first piece of tack. Within three weeks I was getting three or four different horse magazines, asking me to order items. How did they know? They knew because I used a credit card for that first purchase. All of a sudden they can have my complete demographic spending pattern. The magazines I did not order from, I don't get any more, and the ones that I do order from, I now get all the sister versions of those. We are in a society in which information available about individuals is extraordinary. You can exploit that information to address some simple things like vehicle ownership. Some of the data we have struggled to obtain is now readily available.

TRANSIMS is a large and extensive project. It is one of the largest undertakings we have ever done. We are in the formative stages of the project now. We are collecting information. We are looking at ideas. We want you to give us your ideas, your best advice about, what we are not doing, what we are doing that is wrong and if you think our pursuit is worthwhile.

We want to interact with the users. We can learn a lot that way. We may change our opinions, but clearly, as contrasted with merely a research endeavor, we are going to build something. Our intent is to make this available, not five years from now, but portions of it as quickly as possible so that we satisfy the greatest needs quickly and early with our products. But to know what is needed, we have to learn from the users. Clearly there are many things that we are not doing that others have done and can do better. We call that related research activity demand. A part of that is understanding what drives people to go from Point A to Point B during the day. We have proposed an outreach program to assist us in interacting with other relative research important to this project. There are methodologies being developed, Bob Dial mentioned one yesterday and there are others as well, that are quite good that may be relevant to this project. All of these efforts are part of the consideration of requirements and methodology which leads to a design. So this formative phase of the project is the time for information to come in and be shared so that we can better understand what the architecture of TRANSIMS ought to be.

Today we are going to show you what we did in Albuquerque. We wanted to know if we could compute and plan two million trips over twenty-four hours for a city with less than 500,000 population. We did it. We know we can do that. We wanted to know if we could simulate a large number of vehicles fast enough even on medium size machines today. We did that, and I will show you some of the results. And, we wanted to know if we could learn anything by doing this. Once you compute at that level, is it decipherable? Does it show things like latent demand? Indeed it did. Did we validate it; did we calibrate it? No. That is yet to come. But applications are important. Our intent over the next five years is to pick two major applications in two metropolitan planning organization areas to test key policy issues. We want to use this framework to examine them and ask if this makes sense. Out of all of this there is an interesting connection to Track B. It is the connection between the data, models and simulations; how do you build them up? One of the things we can do is use simulations as a basis for understanding the problem. In fact, I learned way back in graduate school that if you can understand the problem any other way, do not simulate it because that is expensive, time-consuming and difficult. Many of you already know that. But when the problem is otherwise intractable, when it defies your imagination, your insight and your intuition, then simulate. It does not mean you have to simulate forever. What you are looking for are insights at the cause and effect level. And on the basis of that, you are able to develop, in many instances, a model that is simple and easier to use, uses less data and is quite satisfactory for the intended purposes. One example of this is that our simulation is tracking things here in detail. Perhaps all of that detail does not have to be tracked. Perhaps not all of those variables are important, but until we simulate at that level, we do not know which items are important. So, this symbiotic relationship between the data that we get, how it feeds the simulation, the data that we produce for the models, all of that fits together in very important fundamental ways.

This morning we have three presentations on key aspects of TRANSIMS. First, Vernon Loose is going to talk about applications and requirements driven by the Clean Air Act and ISTEA. Then, Mike Williams will talk about what policies and requirements initiated this project. And, finally, Steen Rasmussen will conclude by talking about the system architecture.

TRANSIMS Model Requirements As Derived From Federal Legislation

by Vernon Loose, Ph.D., Los Alamos National Laboratory -

Our program plan calls for us to investigate and document the specifications that TRANSIMS should have in order to address the issues and requirements. We are circulating the requirements paper in draft in order to seek your input, your feedback, your reactions. We need to get this right in order for TRANSIMS to be a useful model. So, we are very open and in need of your feedback to understand your requirements. That is why we are starting out at the beginning of the development of the model to address these issues.

Our program plan also calls for us to develop two applications within the five-year development period of the TRANSIMS project. We have begun to investigate the issues and requirements through discussions with MPOs and others of the user community to identify sites, interests and useful and necessary policy issues for which TRANSIMS can provide useful information.

Our perspective is that TRANSIMS is a response to needs. The needs are to satisfy requirements in legislation but also requirements from your policy environment, the questions your policy and administrative people are asking as well as the community at large. You have indicated that the procedures developed over the last 30 or 40 years are no longer adequate to accomplish what you need to do. So that is where we start from. We start from the need you express for something to address the questions in this new policy environment. And, if I can use an economist's term, TRANSIMS is a response to a demand from the user community.

The policy environment that the user community is facing is based on a foundation of state and metropolitan goals and objectives for the transportation system. The Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991 are major contributors to the issues and requirements that TRANSIMS has to address. And in particular, the ISTEA points to the conformity determinations as requirements to develop the transportation system.

The 1990 Clean Air Act Amendments established attainment standards for six transportation related pollutants. The Act requires transportation planners to determine that major capital improvement projects will not increase emissions. That is, the traffic control measures and projects proposed must be pollution neutral. Title 1 of the Act also mandates that most significant transportation projects must have emissions analyses supporting them. More importantly, the focus of the Amendments is that the new conformity standards require planners to prepare long-range travel demand forecasts and to conduct air quality analyses with sufficient detail to predict the levels of pollution due to increased travel and to changes in design and operation of the transportation system. I realize that I am telling you about conditions that you are very familiar with, and yet we need to emphasize that

TRANSIMS will address these conditions, but we need you to tell us where we have it wrong or where we need to modify it or amplify it to meet your needs. The new requirements are why the TRANSIMS project has been initiated, to assist you in meeting these requirements.

Title 2 of the Act goes further by establishing more stringent emissions standards for cars and trucks produced between 1996 and 2003. What this means for TRANSIMS is that in order to analyze the situation subsequent to 1995, the emissions models must be sensitive to the engineering and design features of the future vehicles. Not only that, but the clean fuel requirements of Title 2 require the use of alternative fuels so the models must also be sensitive to that in the newly designed vehicles. Detail and model sensitivity to these new variables is critical.

The conformity determination conducted by transportation planners will have to verify that the transportation control measures are being implemented and that all the transportation projects have been evaluated and are pollution neutral. The conformity determinations must be based on the latest planning assumptions and forecasts for the particular region and on the latest EPA emissions model. It must include consultation with the air quality community and provide for timely implementation of TCMs.

To go one layer further into the development of plans in an urban area, the SIP development process must take place in states and metropolitan areas. The major components of the process are the national ambient air quality standards for six pollutants. The SIP process requires an emissions analysis with projections of specific pollutant emissions by source and development of emissions budgets over the planning horizon so that for each different mode, cars, public transportation, other modes, you have to develop budgets of emissions outputs. These emission budgets have to be scheduled with transportation control measures so that at some future time the implementation of transportation control measures will achieve attainment.

Thus, the CAA results in a long list of air quality requirements for transportation planners. There are other requirements far too numerous to list.

We say that the development of TRANSIMS is going to be applications driven. The reason we are emphasizing applications is that we feel that applications are important to drive the model. They help us to assure that the specifications of the model are suited to real world needs. If TRANSIMS is going to be used, we have to insure that it addresses the issues of interest to the practitioner community.

Applications also provide for incremental designing and testing. The process of developing an application, structuring a model to address a particular policy issue, will help us design and test a model. This offers an opportunity to deliver intermediate products; you are not going to have to wait five years to get some benefit from TRANSIMS. We very much want to develop intermediate products which will aid policy analysis for which TRANSIMS will be used to address particular issues in two Metropolitan Planning Organizations that we will select in the future. They also offer an opportunity to integrate research results. The research, the model development and applications are proceeding virtually simultaneously, and we can integrate research results into the application process as those research results come forward.

Finally, and perhaps most importantly, it guarantees interaction with the user community. It forces us to interface with the user community on a day-to-day basis and to so structure the model. To develop the applications, we have to select and design the application. When we select a site and an application, we will develop a detailed study design with the associated MPO to structure the model to address that application. We have to go through a data acquisition phase, and then of course, implement the application. The process will give us an opportunity to spin off interim products and will provide an environment for the validation of the model and for doing sensitivity analyses.

As I mentioned, we have begun that process and we have the draft issues and requirements paper. We have completed two MPO visits, Dallas/Fort Worth and Boston. We have scheduled visits to San Francisco and Portland, Oregon, for September, and our final visits to Denver and Chicago will be later in the fall. But in addition to the MPOs, we are aware that the requirements for TRANSIMS may stimulate interest from other organizations. So we are planning visits to the Florida Department of Transportation and one other, as yet unspecified, state department of transportation. We are going to visit with the EPA and the Environmental Defense Fund. We need to establish contact with those organizations to include their views and needs. And then too, private consulting firms that provide services to the user community will be contacted.

Finally, I would like to give you a thumbnail sketch of the results of our visits so far. We are entering a new environment. We need to learn a lot, and that is the reason for establishing contact early on, up front with the user community. Our eyes were really opened by our visits to Dallas/Fort Worth and Boston. We gained a great deal of knowledge about the actual planning environments that TRANSIMS is going to be used in. We need to learn a lot more about those environments. Not that we are the judge, but it is always nice to be able to work with good people, and we would be honored to work with either of those staffs to develop applications. They are doing well to address the required issues even though they know that some of their tools are limited. We learned that we are probably going to be facing very different and unique planning environments. We expect that we will continue to see that when we visit other MPOs. The planning environments in the different cities, the things that are important will vary from city to city. We expect this. TRANSIMS has to be adaptable enough to address these different environments.

In our visits to Dallas/Fort Worth and Boston, we also found out that it is extremely important to get early and rapid detection of incidents so that they can be mitigated, so that negative impacts on air quality can be reduced. We learned some interesting things about off-street parking regulations which Neil Pedersen was talking about yesterday. In Boston the parking regulations may cause an unduly large number of cold starts when people are moving their cars around to comply with the off-street parking regulations.

In summary, the process of defining requirements to determine an application selection has begun. We see requirements and applications as closely linked and extremely important and we sincerely seek your guidance and input to this overall process. We need to have that input in order to make sure that TRANSIMS is a useful model in the end.

TRANSIMS Methodology

by Darrell Morgeson, Ph.D., Los Alamos National Laboratory

I want to go briefly through the methodology of TRANSIMS, but before I begin I would like to make one comment. What is the surest way that TRANSIMS can fail? In my opinion, it is trying to do too much for too many people. It is trying to be all things to all people. Even though it is broad and treats a lot of issues, we have to narrow that through a well defined set of goals or else we will tack on thing after thing and never get anything accomplished. I know that with this budget and this time frame there is a feeling that it ought to solve all things for all people. I hate to dash your expectations, but I do not think that we will do that in this time frame.

Having said that, I am going to show you the work in progress. Some of this we are in the process of doing and I hope not to get into the philosophical discussion of how we will do that.

To start we had to treat demand generation. We put together synthetic populations and travel itineraries. The fundamental inputs are representations of the intermodal transportation network and some estimation of the load based travel demand. Load is a general term that includes passengers and commodities. This is conceptually a nested computational loop executed for everything to be moved. The program computes trip plans for two million people across the transportation network. Once the two million plans have been created, we estimate how they interact with one another in time and space, spreading those out along the network until the trip plans reach an equilibrium. This spreads the trips in space and time along the alternative routes of the network.

The trip plan generation is really very simple and is related to travel behavior modeling and decisions. The first step is destination choices followed by mode choice decisions. We start with network properties including distances and link distances through a generalized cost approach. We transform the objective description of the transportation network into the subjective view of the traveler from the population on the travel demand list, including their individual preferences and choices and their view of the transportation network. When they reach a node, they make a decision to continue driving their car or take another mode. As we do this for each individual, determining how to get from here to there, the program recomputes the costs based on a generalized cost equation where the cost of traversing any link is a function of the operating cost of driving a car or taking transit, but including time cost. Every time you approach a node, you recompute all the alternative links from the node, based on that cost equation.

Computationally then, the algorithm is simple but not intuitive. As I approach any particular node, I compute the cost of exiting that node on all the alternative links. So the intermodal decision is made at the node. The probability of choosing a link is inversely proportional to its length so the shortest link is more attractive. Using a Monte Carlo simulation, one link is selected. At any particular node, I can go in any different random direction. The selection is biased on the basis of the least cost and in a direction generally in favor of satisfying your goals. While it is non-intuitive, the algorithm works very well. It finds a good path in about 95 percent of the cases. When it does not find the optimum path, it finds candidates that have some slight variation. It produces a family of paths that have slightly higher costs. For a whole population of drivers from here to there, random variations might be attributable to stopping at a gas station or some other random deviations.

The first computational step produces trip plans for everybody. The next thing to do is to compare them. Every individual, every household has goals it tries to achieve, such as getting to work by a certain time or not exceeding certain costs. So the next step is to project the plan. How long would it take under predicted traffic conditions to execute the plan and how much would it cost? Then compare these measures to the goals of each traveler or commodity. The goals do not guide the route or mode of selection. Those are functions of the cost equation, but the goals do determine whether or not the trip plan is acceptable. Some examples of unsatisfied goals are maximum, minimum costs; not later than arrival time; not earlier than departure time; and others. You can combine goals, such as having an adjusted time of arrival. You compare the goals with the trip plan. If it meets all the goals, then the trip plan can be loaded to the network. The trip plan may look like it is going to do everything the traveler wanted it to do, but if all goals are not satisfied, the process is to look for alternative trip plans. The program searches for new time of departures. This process is called preference adjustment.

Preference adjustment deals with trips independently, one at a time. Briefly, here is one example of what the preference adjustment phase does. The traveler might have a desire or a preference to avoid downtown or high crime areas, but the trip to one of his activities puts him on an interstate highway, a safe route, a leisurely route, but it doesn't get him there on time. What happens is that his preferences change, such as the attractiveness or unattractiveness of certain areas. That is called preference adjustment. What the methodology actually allows is to dynamically change preferences and then look for different trip plan solutions. If the first solution meets part of the travelers' goals, in this case going on the interstate highway, but it does not get them there on time, they can seek alternative solutions through areas that they normally would not go through if their time goal had been met. The goal in the first step is to get as many goals satisfied on the trip plans as possible and try to reduce this number to zero. But that is not possible in all cases. There may not be a solution that will satisfy all goals. An example of that is inner-city people who want jobs in the suburbs but cannot get to those jobs because they have no car or transit available. Therefore, their trip cannot be planned and the demand is unsatisfied.

The planner represents a best guess. All kinds of complexities occur that are not accounted for in the planner unless they happen consistently from day-to-day. Persistently. What we seek to do in the microsimulation is to execute the plan. The program actually puts together representations of cars and drivers and their driving behavior; each driver with his own profile. That is what a car driver in the microsimulation does. It tries to execute the trip plan as best it can. If it gets very far from the goals, then we replan the trip. At one second intervals, we go through and update all of this and make decisions on where to pass, break, stop at traffic signals. The turning kinds of behaviors are not imposed on the cars and drivers; they are a function of executing the route plan. So when I come to a node, I turn left or right based on what my plan has indicated. It is at a regional scale. We track acceleration engine temperatures because we have to drive to provide input for the environmental models. We use object oriented programming to represent this information.

The idea of synthetic populations is something we developed to drive the intermodal planner. We started with a survey done for the MPO in Albuquerque that included 2,100 households. We synthetically produced a population of roughly 400,000 people. The process produces the households and the activities that each household engages in. We picked out a set of demographic variables and asked the question that, "if I am producing a new synthetic house to expand my population, what would be the probability that this particular characteristic exists in the new house?". Some proportion of the actual houses would have that characteristic, and that proportion was used to produce a probability density function for that characteristic. We then drew from that density function to determine the probability of households with that characteristic. So we created new houses and new people that looked very like the old houses of the old people but had this nice sort of random variation.

Travel itineraries of all households were collected in the travel survey. Activities that the household engaged in during the day were also identified. We expanded and produced new synthetic activities which again looked very realistic but were not exactly the same as the original population. In determining the destination choice for each one of these, we did something simpler yet. It was similar to an inverse gravity method that you use in the four-step planning process to say where these would occur, and we associated goals for every one of them.

The data sources that we are developing fit in two phases: generation of the household itself with all of its activities and then the destinations and the goal choices of each one of those. This is a somewhat sensitive area for us right now, but we are working with some commercial or private sources to look at what new kinds of information might be available. I will tell you only that these are promising and sensitive. And putting all of these together, we think they yield interesting composite pictures.

You can make some rough comparisons between the four-step planning process and what we do in activity demand or generation of loads, and households, and destinations. If I look at the steps of generation and distribution in the synthetic household population, associated with each household is certain information about where it is, income levels, and we produced the destinations and trip goals. The generation and the distribution steps are embedded in the synthetic populations in a consistently disaggregated manner. So it is roughly comparable to the four-step planning process.

For example, consider several simple trips: first, home, work, home. Another one is slightly more complicated: home, drop the kid off at school, go to work, pick the kid up at school and go back home. A third is even more complicated, come home at noon, eat lunch, go shopping, take the wife shopping, come back home, go back to work, come back home. These are examples of itineraries. We constructed a vocabulary of letters to form words that describe the trips. These words form a vocabulary which if complete includes all trips in the city. The Monte Carlo simulation is then used to randomly produce new synthetic itineraries based on letter combinations to create words. All of those look very much like the original itineraries, but have random properties so that not all households are the same. Then we just associated the time you came back home with a trip chain, and these particular itineraries would represent trip chains. By tracking the time of day and engine temperatures, you get the effect of cold starts and other emission generation.

One of the things that we are trying to accomplish today is to view this as integrating framework with other relevant research and methodology and to try to identify those things in this meeting and in our interaction with the research community.

Within the planning area, you are making estimates based on your best guess of what traffic conditions will be. The simulations are producing better estimates of real traffic conditions, so there is that feedback.

All of this is an exercise in uncertainty. As we could not see ten years ago what we have today, we cannot clearly see ten years from now. But we are computing at the fundamental cause and effect level. It does not make sense to go much beyond that because you get down into molecules and such. It is theoretically possible but not very practical. Flexibility comes not from what TRANSIMS might be at its first level of production, but what we might learn from it to produce more simplified versions and better focus on what is really needed and important. The other thing that drives us to flexibility is to produce something that responds to the requirements and needed flexibility.

Use of TRANSIMS for Air Quality Analysis

by Michael Williams, Ph.D., Los Alamos National Laboratory

The goals for the TRANSIMS modeling system look something like this. We want to be able to translate traveler behavior into spacial and temporal air pollution concentration. The reason we are really interested in this project is that we do not think we do that very well right now. We skip the travel behavior, and we only deal with aggregate systems. What we will put into this system are itineraries, vehicle mix, driver personalities that will go into the traffic simulation model that you have heard about. From that we will get distributions of speed and acceleration, catalytic converter operations and engine temperatures. That goes into the emissions model, and from that we get spatial and temporal distributions of various pollutants.

From that you can go to a dispersion model. This is a fairly sophisticated Monte Carlo type model. It will produce concentration fields of things that do not react very much in the atmosphere such as carbon monoxide. You can also go to the air chemistry model and get out things that do react in the atmosphere: ozone, oxides and nitrogen and hydrocarbons, and also aerosols. Now from the other side, we are bringing in large-scale weather data and that goes into an atmospheric model. This is the kind of model you use to predict the weather. It is driven more by local conditions. It knows the fact that you have an area, an urban area as opposed to farmland. It is very sensitive to terrain. It produces turbulence fields and wind temperature fields. We anticipate that traffic engineers, urban planners, environmental scientists, air quality regulators and health scientists might use this to estimate such things as the impact on air quality when instituting mass transit systems or building new highways. These are the things we do not get in the current systems of modeling, including different vehicle mixes, traffic jams, stoplights, tollbooths, that sort of thing.

I am attempting to approach the air quality analysis needs as a user. I would like to be able to get good emissions data, and I would like to be able to really understand what is going on in our cities in terms of air quality. We have basically three kinds of tools to deal with that. We have a set of measurements, we have a set of emissions estimates, and we have the models. And yet, the current status of our understanding is not very good. We need to work all these three pieces together in order to get a better understanding. The modeling can tell us something about the representativeness of the measurements. For instance, in Mexico City we found that the balloons one uses to measure weather conditions are providing the data that drives the meteorological models throughout the world. However, they traverse the turbulent layers so quickly that they do not give us a very representative value of wind direction. So that is an idea of how modeling can help us understand what our measurements are really telling us. On the other hand, of course, measurements help us to understand whether the models are working properly.

What are we going to do differently in TRANSIMS? We are putting in traffic flow parameters and emissions that are calculated as a function of space and time. We account for fluctuation in traffic, abnormal congestion and intersections. Typically you only get these things in a crude fashion, or you have to specify them specifically for each case if you use the traditional modeling techniques. We are driving the system with a prognostic meteorological models which allows us to look at variable speeds and wind directions. Its continuous stability is particularly good for complex terrain. And one of the things that we are finding is that there is a link between the slopes and the emissions that result as cars go up a grade; and, of course, those same slopes will drive the meteorology, so it is important to tie these things together. Typically, traditional techniques do not treat these things well. The kind of emission model we are talking about is still in the developmental stage. It is very important that we get these speeds and accelerations, engine loads and things like that, and from that we can put out carbon monoxide, hydrocarbons, NOX and aerosol emissions. Why is acceleration so important? It turns out that one second under high acceleration puts out as much ozone as 2,500 seconds under normal operations based on actual measurements.

For the emissions module development, we are looking at the current status based on the federal test procedure driving cycle. EPA MOBILE is based on that sort of thing. What we are going to do is extend work of the California Department of Transportation into the regimes of heavier accelerations. The heavy emitters are another thing that we picked up from remote sensing, and we will be able to incorporate that. We also will deal better with cold starts because of data coming more directly with our simulations. We are also working with Georgia Tech, and there is a recent University of Michigan study using data from auto manufacturers.

The kind of components that we are talking about for this system include the mesoscale meterological model which we have and we are continuing to develop; the emissions model we do not have; a set of algorithms that represent the California work and some of the high accelerations (we need to extend that to more vehicle types although I believe we have the right general kinds of behavior; the random particle dispersion model which allows us to treat that in a sophisticated fashion; and, the air chemistry model which is, of course, the right way to treat ozone and things of that nature.

What do we think of the strengths of this system are? Integrated traffic, emissions meteorology and air pollution models. The prognostic meteorological models that are predictive three dimension time dependent meterological models are a flexible tool for analyzing "what it". You choose to build a freeway somewhere and you know that the area will become more urban, and that will actually change the local meteorology. We can reflect that in this kind of system. We can address problems ranging from tens of meters to hundreds of kilometers in scale. We can account for spacial and temporal flux in traffic flow and emissions. Right now, it looks like in certain cases such as with CO, they are dominated by abnormal situations. They are dominated by emissions from cold starts, from high accelerations and heavy emitters. They are dominated by the typical kinds of emissions.

In summary, that is what we are contemplating and I have great hopes. I believe that if we do not use something like this, you have to be a little pessimistic about our ability to understand air quality in urban areas.

Interim Remarks

by Darrell Morgeson, Ph.D., Los Alamos National Laboratory

I know the morning is drawing long here so we will try to be brief about the remainder of the presentations. I would like to review the study we did in Albuquerque and show you some of the results, the data outputs, some of the phenomena that we observed. We did a very simple thing in Albuquerque. We planned the entire city for 24 hours. We took those trips that just utilized the I-25 and I-40 exchange. Albuquerque is very regular, north, south, east, west like that. All of the trips that appear in a certain block of time on those highway segments were simulated. Then we introduced a mass transit system, such as a train system or bus system. These paralleled the interstate so that we made it available to cars and drivers that were the baseline using the interstates. We made use of the transit system part of their preferences and goals. And some of the results calibrated to what we thought would happen, with our intuition, and some did not. We supposed that the total number of freeway trips during rush hour would go down. They did. What we did not expect going into the exercise was that the total number of vehicle trips overall during this time period would increase. They did. They increased because of the availability of cars from the workers who were using the buses were then left at home. And also, because there were latent demands to go shopping and do other things, that were not being accessed before, the total number of trips went up. The overall duration of the trips went down, because the trips were local trips, shopping and school trips. And because the total number of trips increased, the total trip length went down. And from that, you might conclude that you were dealing with colder engines, which we were. And so, if you work through the results, the overall pollution went up because you had a facility like mass transit put into place. The environmental transportation planners did not like to see that and so we did not want to announce it. But, that is what the model is showing. So in some sense if you think about it, you can calibrate your intuition that way.

TRANSIMS Microsimulation System Architecture

by Steen Rasmussen, Ph.D., Los Alamos National Laboratory

I will briefly review the issues that are associated with the architecture of this type of high-speed simulation. Given the time we have available, we cannot get into too many details, of course. I will only talk on two issues. The first is high-speed simulation in large complex systems and some of the experimental design of the simulation of these dynamical systems. Once you allow a system to become dynamical, a lot of things happen. And most of these things are emergent. That is, they are not encoded in the system. For instance, when you think about the concept of a vehicle, you do not have any definition of congestion. You also do not have any definition of congestion when you look at a roadway. But once you put lots of cars on a roadway and you allow them to interact, you get congestion. That is an example of an emergent phenomena. Travel times are emergent phenomena. Pollution and air quality are emergent phenomena. Incidents are emergent phenomena. We want to generate these dynamical phenomena and also to detect and figure out which ones are important.

In large systems such as those we are describing, that is not a trivial task. So, one of the issues to consider first is to make a very fast regional microsimulation of traffic. If we want to be able to simulate say ten to twelve million travelers interacting in Los Angeles, we need to be able to produce in those simulations in the order of one hundred million vehicle seconds per second, which is quite a lot. And to do that, we have to use a lot of tricks. We have to use large computers, but that will not do the trick alone. We also have to use simplified driving models for some of our simulations. We have to simplify the way we produce the vehicle dynamics. It is essential for this simulation to run really fast in order to control the fidelity of the individual objects in the simulation. I will explain more about that shortly.

We have been working quite a lot with large systems, but we are not quite there yet. I believe, however, that it is indeed possible to get there soon, within the next year or so. We have produced some phase transitions and spontaneous structures in this vehicle traffic. We have been looking at congestion pricing and some of the self-organizing phenomena that occur on the simple networks when that is introduced. We are also working different algorithms to address the whole new box of problems that you get into when you work with high performance computers. We have to determine how we put these systems on multi-computational machines which means we also have to have self-organizing algorithms to take care of how the control of computations actually occurs.

Let me just give an example of what we have done here (shows slide). This example has to do with the so-called cell audiometer simulation of traffic. Unfortunately, I can't get into the details of the algorithm, but basically the output of the system as shown here is a space timed diagram. This is a simple example. We have a single lane and a single lane goes from here to here or from here to here. What we see are a lot of dots and each dot is a vehicle. And this represents an evolution in time. The time goes downward. When you look at these here, these are indications for vehicles at different times and different places on this little link. All of these pictures here on the left-hand side are taken from a little below maximum capacity. And these pictures here are taken a little above maximum capacity. What you see here is that even below capacity, we have the occurrence of congestion which is indicated by these backward traversing waves. One of the things that we did not know is that you have a merging of these traffic jams. But, you actually have critical dynamics at the transition. That, of course, is interesting if you are a theorist, but what does that mean? Does it mean anything at all? It does. Look at the fundamental diagram; you are all familiar with it; this is the density of the roadway traffic. Actually, this is from simulation. We do not have quite as much variation as we see in real traffic measurements. Once we put in the truck characteristics, we get some more variance. We get also these two typical different slopes below capacity. We will be able to improve this as we work with it. But, maximum capacity is about .08, and this is where most cost can go through, the flow is on the y axis here.

Now consider criticality. What does that mean? It means that the variation of the travel time is a function of density. Once the traffic volume hits capacity or is in the vicinity of capacity, then the uncertainty of how long it takes to traverse that link explodes. The travel time uncertainty well below capacity is very low because you are more or less driving like you own the road. You do not need to interact with other vehicles. But once you reach capacity, you have the occurrence of an infinite number of congestion points. What we can show mathematically, is that below capacity we can have traffic jams. We can have congestion points, but the probability of very large traffic jams is very, very low. But at capacity, an infinitely large number of traffic jams emerge. That is the point at which we go from about four percent uncertainty of the travel time given desired speed on a single link to almost 70 percent uncertainty. It is actually quite amazing to think about this because what we would want to do when we are building our infrastructure is to utilize it as best we can. So we would like to have everything operating at capacity. In particular, all these informational systems (e.g., IVHS) that we are thinking about putting into use are intended to take traffic from crowded roads and put it onto less crowded roads. That means that we are producing a self-organizing critical system. And that means that, first of all, since any incidents at this point will, in principal, greatly propagate traffic congestion, our systems in a mathematical sense, are not controllable. So to estimate or predict the function of these systems at capacity is, at least in mathematical sense, not possible.

Those are some issues that we have to think about when we are talking about these informational systems. In this area there are two contradictory directions. One has to do with controllability and the other one has to do with the flow. There are some ways out of it. The obvious one is that we have to make sure that these informational systems push the density down below the capacity so that we do not run into the critical regime. Another thing which we should note is, that when we are in a situation where we have lots and lots of acceleration and braking and where we go from high speed to low speed, that is exactly where we produce the most pollution. So we get very foul air if we operate at capacity. And thirdly, a philosophical point is that we probably have the most severe accidents at maximum capacity since it is just common sense that when you go from high speed to low speed to high speed to low speed you have very varied kinds of driving.

These are some issues I am emphasizing because they cannot be captured by using the equilibrium methods. We are talking about calibrations between the microsimulation and the planner. One of the things that is useful when we calibrate is that we know we are right when we have maximum divergence in the planner (i.e., congestion and traffic are widely spread). I want to emphasize that because there has been a lot of discussion about equilibrium and it has some real problems.

One other thing I want to say before I close is that with these simple models, we cannot say anything about accidents because the models are designed in a way that we cannot have accidents. They are consistent so that you do not get collisions. If you want to look more into these situations, we have to use intelligent objects that were mentioned earlier. We are working on an integrated simulator that can both have these very simple and more complicated representations of the traveler. You can switch between them depending on which questions you are asking and also the conditions in your system.

Closing Remarks

by Edward Weiner, U.S. Department of Transportation

We feds have compared notes during this conference, and I would like to give you some reaction to what we've heard. First of all, the conference has been far better than we had any right to expect. We have just been stunned at the amount of information we've received. I have said to a couple of people, what else should we expect when we hold a conference only every 15 years? The information kind of builds up.

The feds are clearly struggling with their role here, and if you have some views on this subject, feel free to make them known to us. We are working from the inside to try and get more of a cooperative role, a proactive role for the feds, who have not been very active in this role for the last 15 years or so. It doesn't hurt us to hear from the people on the firing line that this is a problem. We can report that this is a problem, but if we get letters and hear and talk to people who say that it's a problem, that helps as well.

We will go back and try and deal with as many recommendations as we can, but the list is overwhelming. In our group, the lists were very long. But, even though you may have heard the same recommendations from other workshops, all were worth hearing. Even though the top ten may need to be addressed first, that doesn't mean that the rest of them don't need attention. We'll do our best, but the level of expectation is so high that we hope not to disappoint you by our response.

There will be proceedings from this conference. We've talked about having another conference next year and for them to be ongoing. We will do our best to get as much information out as fast as we can. I think part of the concern about this program being a closed system is that there aren't enough people to get information out fast enough. This conference was one attempt to try to do it en masse, but we know we have to do more.

Thank you for your participation. Every person here has contributed an amazing amount. It's been a very high quality professional operation, and we are thrilled about the results.

List of Attendees

Name	Affiliation
Bernard Alpern	URS Consultants, Inc.
Cathy Arthur	Maricopa Association of Governments
Gene Bandy	Baltimore Metropolitan Council
Patricia Bass	Texas Transportation Institute
Moshe Ben-Akiva	Massachusetts Institute of Technology
Julian Benjamin	North Carolina Agricultural & Technical State University
Jim Benson	Texas Transportation Institute
Kathryn Berkbigler	Los Alamos National Laboratory
Chandra Bhat	University of Massachusetts, Amherst
Lawrence Blain	Puget Sound Regional Council
Jon Bloom	Minnesota Department of Transportation
Jerry Bobo	Houston-Galveston Area Council
John Bowman	Massachusetts Institute of Technology
Mark Bradley	Hague Consulting Group
Dan Brand	Charles River Associates, Inc.
Jeffrey Bruggeman	Peat Marwick Main & Company
Jim Bunch	COMSIS Corporation
George Cardwell	Maryland National Planning Commission
Ken Cervenka	North Central Texas Council of Governments
David Clawson	AASHTO
Patrick Costinett	KJS, Associates
Charles Crevo	Vanasse Hangen Brustlin, Inc.
Gary Davies	Garmen Associates
John Davis	Los Alamos National Laboratory
Stephen Decker	Cambridge Systematics, Inc.
Robert Dial	U.S. Department of Transportation/Volpe Center
Rick Donnelly	Parsons, Brinckerhoff, Quade & Douglas
Bruce Douglas	Parsons, Brinckerhoff, Quade & Douglas
Fred Ducca	Federal Highway Administration
Jerry Faris	Transportation Support Group
LiYang Feng	Denver Regional Council of Governments
Erik Ferguson	Georgia Institute of Technology
Kim Fisher	Texas Transportation Institute
Chris Fleet	Federal Highway Administration
Michael Florian	INRO Consultants, Inc.
Tom Golob	University of California, Irvine
Konstadinos Goulias	Penn State University
Zachary Graham	Texas Department of Transportation
Ed Granzow	The Urban Analysis Group, Inc.
John Hamburg	JRH Associates
Susan Handy	University of Texas at Austin

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James Harvey	Regional Planning Commission (New Orleans)
Greig Harvey	Deakin, Harvey, Skabardonis, Inc.
David Hensher	University of Sydney
James Hogan	Metropolitan Washington Council of Governments
George Hoyt	George Hoyt & Associates, Inc.
David Hyder	North Carolina Department of Transportation
Michael Jacobs	U.S. Department of Transportation/Volpe Center
Martyn James	East West Gateway Coordination Council
Bruce Janson	University of Colorado - Denver
Ron Jensen-Fisher	Federal Transit Administration
Jon Kessler	Environmental Protection Agency
Ryuichi Kitamura	University of California - Davis
Deborah Kubicek	Los Alamos National Laboratory
David Kurth	Barton-Aschman Associates, Inc.
Terry Lathrop	City of Charlotte, North Carolina
Keith Lawton	METRO Planning Department (Portland)
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Richard Marshment	University of Oklahoma
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Bill Martin	Barton-Aschman Associates, Inc.
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Michael Morris	North Central Texas Council of Governments
Elaine Murakami	Federal Highway Administration
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Norbert Oppenheim	City College of New York
Eric Pas	Duke University
David Pearson	Texas Transportation Institute
Jay Pease	Southeast Michigan Council of Governments
Neil Pedersen	Maryland Department of Transportation
Eugenia Pogany	North East Ohio Areawide Coordinating Agency
John Poorman	Capital District Transportation Commission, Albany
Dick Pratt	Richard H. Pratt, Consultant, Inc.

List of Attendees (continued)

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Chuck Purvis	Metropolitan Transportation Commission, San Francisco
Karl Quackenbush	Central Transportation Planning Staff
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Matt de Rouville	Baltimore Metropolitan Council
Raymond Ruggieri	New York Metropolitan Transportation Council
Earl Ruiter	Cambridge Systematics, Inc.
Larry Saben	COMSIS Corporation
Charles Schaub	Kentucky Transportation Cabinet
Patti Schropp	Atlanta Regional Commission
Gordon Schultz	Parsons, Brinckerhoff, Quade & Douglas
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